

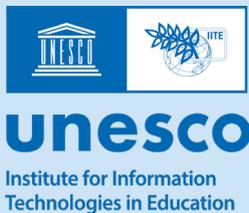
# Smart Education Strategies for Teaching and Learning:

Critical analytical framework and case studies





Smart Education Strategies  
for Teaching and Learning:  
Critical analytical framework  
and case studies



COMMONWEALTH  
of LEARNING



Smart Learning Institute  
Beijing Normal University

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# Abbreviations

AI	artificial intelligence
AIAP	AI Apprenticeship Programme
AIED	AI in education
AR	augmented reality
BECTA	British Educational Communications and Technology Agency
BNU	Beijing Normal University
BRI	Belt and Road Initiative
CAGR	compound annual growth rate
CAIR	Centre for Artificial Intelligence Research
CBE	Competency-based education
CISA	Cybersecurity and Infrastructure Security Agency
CLASS	Computer Literacy and Studies in Schools
COL	Commonwealth of Learning
CORE	Centres of Research Excellence
CSIR	Council for Scientific and Industrial Research
DEE	Digital Educational Environment
DEWS	dropout early warning system
DHET	Department of Higher Education and Training
DLS	distributed ledger systems
DSI	Department of Science and Innovation
DTI	Department of Trade and Industry
EDLP	Early Digital Learning Programme
EKB	Egyptian Knowledge Bank
EMIS	education management and information systems
EPE	Explore Plan and Execute
ERT	emergency remote teaching
ET	educational technology
EWS	early warning systems
FSP	Free Semester Program
GDP	gross domestic product
GNI	gross national income
HDI	Human Development Index
HE	higher education
HSRC	Human Sciences Research Council
IA	intangible asset
ICT	information and communication technologies
ICTE	ICT in education
IoT	Internet of Things
IP	intellectual property

IPOS	Intellectual Property Office of Singapore
ISO	International Standards Organization
ITS	intelligent tutoring systems
JCSE	Joburg Centre for Software Engineering
KERIS	Korea Education and Research Information Service
LMS	learning management systems
M&E	monitoring and evaluation
MAIC	Mauritius Artificial Intelligence Council
MCIT	Ministry of Communication and Information Technology
MEE	Monitoring of the Education Economy
MEITY	Ministry of Electronics and Information Technology
MOE	Ministry of Education
MOOC	massive open online course
MTT	Ministerial Task Team
NASSCOM	National Association of Software and Service Companies
NCCE	National Centre for Computing Education
NDP	National Development Plan
NEA	National Education Association
NEIS	National Education Information System
NETP	National Education Technology Policy
NHS	National Health Service
NII	National Information Infrastructure
NLP	natural language processing
OEP	open education practices
OER	open educational resources
OMO	online-merge-offline
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
PSET	Post-School Education and Training
PwC	Price Waterhouse Coopers
QC	quality councils
R&D	research and development
RUP	responsible use policies
SACE	South African Council of Education
SEL	social and emotional learning
SIDS	small island development states
SLR	Systematic literature review
SLS	student learning space

SME	Small and medium-sized enterprises
SMT	student mapping tool
STEM	science, technology, engineering and mathematics
TCO	total cost of ownership
TELI	Technology-enhanced Learning Initiative
TVET	technical and vocational education and training
UVUCA	unequal, volatile, uncertain, complex and ambiguous
VET	vocational education and training
VR	virtual reality
WEF	World Economic Forum
WSIS	World Summit on the Information Society

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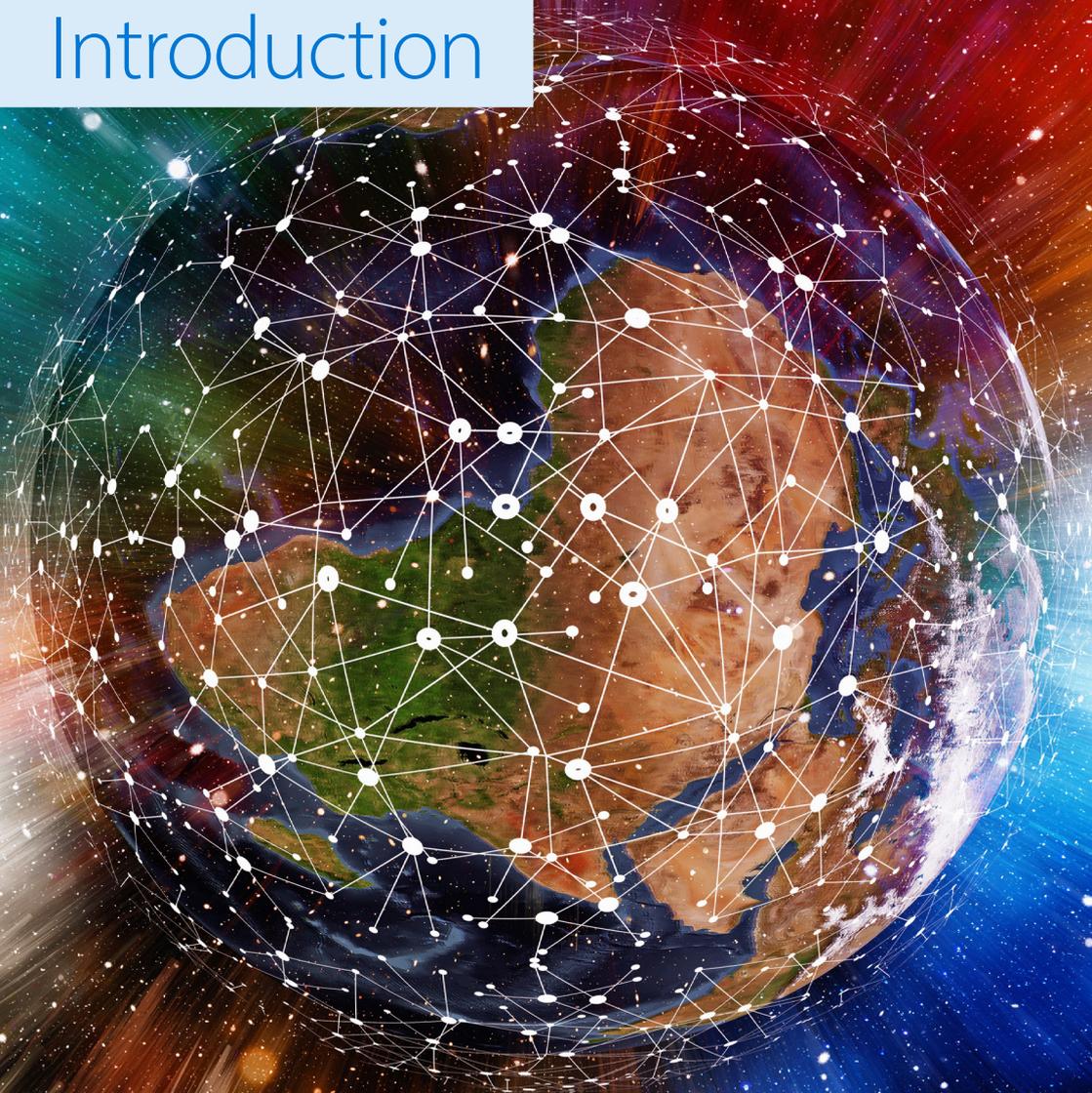
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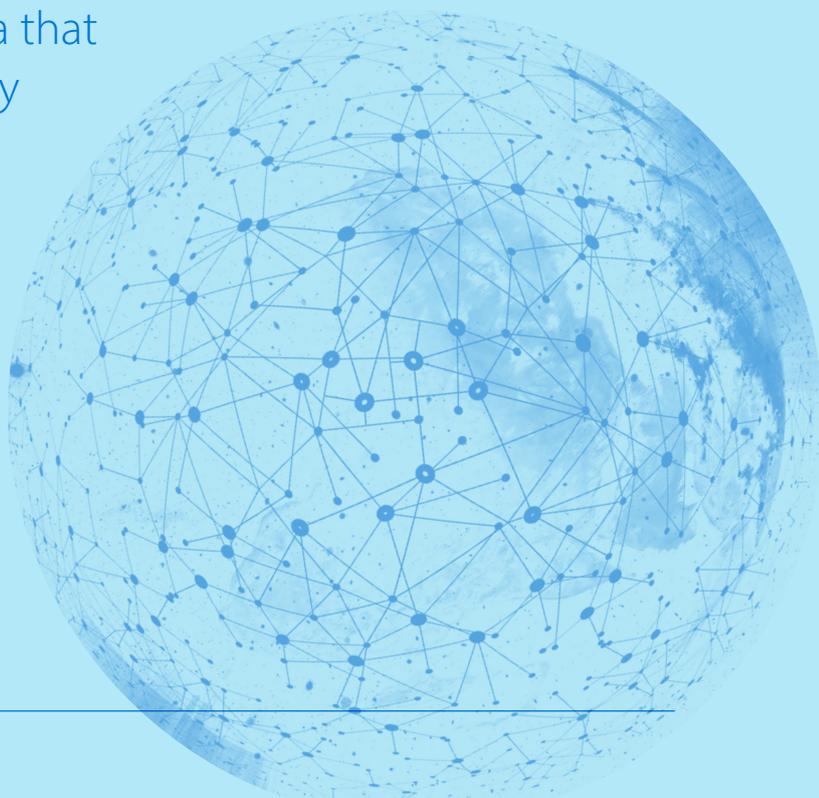
# Chapter 1

## Introduction



## Introduction

While information and communication technologies (ICT) have been part of global and national education policy discourse since the 1980s, explicit national public policies on ICT in education (ICTE) emerged only in the 1990s under the influence of globalization. These were then informed in the early 2000s by global frameworks that served to enable policy formation to guide and influence national ICTE policy development. The key frameworks were the Millennium Development Goals (2000), and later, the Sustainable Development Goals (2015) and the related Qingdao Declaration (see UNESCO, 2015a), the World Summit on the Information Society (WSIS) Declaration of Principles and Platform for Action (2003), the Broadband Commission on School Connectivity (Broadband Commission for Sustainable Development, 2020) and, more recently, UNESCO's Recommendation on Open Education Resources (2019) and UNESCO's Guidelines for ICT in Education Policies and Masterplans (UNESCO, 2022a). These global frameworks have mobilized networks of powerful public, private and civil society players to scaffold a global ICTE agenda that combines often contradictory rights-based, social justice and economic competitive objectives.



## Emergence and evolution of national ICTE policies and frameworks

Successive global ICTE frameworks since the early 2000s have tried to standardize diverse policy processes and set the parameters to allow national public ICTE policies to be compared. They have also shaped a global and national discourse on ICTE and the role of ICTE policy.

Hinostrza (2018) identifies three successive waves of national ICTE policy formation over three decades preceding 2018. There was a move from a focus on ICT infrastructure access in the late 1990s (wave 1) to greater emphasis on technology-enhanced learning and teaching in the classroom, teacher development and content (wave 2) to more emphasis on pedagogies, learning science and open educational resources (OER) (wave 3). Some would argue that a fourth wave is on the horizon, with growing investments in exponential technologies such as artificial intelligence (AI) and robotics in education (Hussin, 2018). In addition to Hinostrza (2018), Kozma (2011) and Trucano (2016) also provided maturity models of ICTE development within a particular framing of economic and human development and how these manifest at country level.

Trucano (2016) identifies four policy stages: Latent, Emerging, Established and Advanced. These stages are mapped against eight themes: Vision, ICT Infrastructure, Teachers, Skills and Competencies, Learning Resources, EMIS, M&E Assessment Research, Equity Inclusion and Safety. This model includes extensive references to the importance of evidence-informed practice and policy.

Kozma (2011) designed a knowledge ladder framework based on four complementary models on a perceived progressive trajectory in the transition towards a knowledge economy: Basic Education, Knowledge Acquisition, Knowledge Deepening and Knowledge Creation. Each of these models has concomitant education policies, classroom pedagogies, curriculum, assessment and institutional organizations that enable governments to map a possible trajectory towards knowledge creation systems as manifestations of a high road to economic and social development.

While these frameworks have been widely applied to many national policies on ICTE, digital learning and teacher competency frameworks, their limitations have been critiqued for being linear, decontextualized and deterministic (McGarr, 2019).

## Education, artificial intelligence and the fourth industrial revolution

Under the influence of prevailing global frameworks, many countries developed ICTE policies and implementation plans. The collective experience of ICTE policy development and implementation over time, coupled with rapid change and diffusion of digital technologies, exposed the limitations of the prevailing models and frameworks and revealed the ICTE policy space to be substantially more complex and contradictory than previously assumed. The rapid growth in and diffusion of exponential technologies such as artificial intelligence (AI), blockchain and the Internet of Things (IoT) in key economic sectors led the World Economic Forum (WEF) to proclaim the onset of a new quantum or exponential technological paradigm: an emerging fourth industrial revolution (4IR) (Schwab, 2016). A Price Waterhouse Coopers (PwC) report titled *Sizing the prize: PwC's global artificial intelligence study: exploiting the AI revolution* (PricewaterhouseCoopers, 2017) estimates that AI could contribute US\$15.7 trillion to the world economy in 2030, an amount greater than the combined GDP of China and India.

The WEF's influential narrative on the 4IR, along with a host of prominent global conferences such as AI for Good organized by ITU and UNESCO's Mobile Learning Week (UNESCO, 2019b), further gave way to global frameworks and guidelines on AI in education such as the Beijing Consensus on AI and Education. By 2018, more than forty countries had developed either a policy or national strategy or a task force on AI because of renewed global attention to the

need for policy on 4IR and AI. The strategies are based on different aspects of AI policy – for example, research and development, capacity-building and skill development, education, public and private sector adoption, ethics and inclusion, standards and regulation, data and digital infrastructure.

In addition, UNESCO and its partners embarked on a worldwide consultation process on the future of education under the banner *Learning to Become*. This process builds on reports published at key historical junctures of societal transformation, including *Learning to be: the world of education today and tomorrow*, *Learning: the treasure within*, and *Rethinking education: towards a global common good*. The latest publication addressing this philosophical development is UNESCO's 2021 report *Reimagining our futures together: a new social contract for education* (2021a), which calls for an education system that repairs injustices while transforming the future. It urges the intentional use of technology to advance human capabilities to make the world more inclusive and sustainable.

These forward-looking frameworks anticipate a more unequal, volatile, uncertain, complex and ambiguous (UVUCA) world influenced by a growing climate emergency, quantum technological shifts – including advances in the learning sciences and brain science – social and political upheaval, and pandemics. They emerged in the wake of a period when many ICTE policies and interventions had mixed successes and failures. The accumulated global ICTE experience therefore invites a critical approach to the complexities of emerging national policies that are responding to the accumulation and escalation of exponential technologies in education. It is an attempt to inform such emergent policies, referred to broadly as smart education policies.

**By October 2021, many governments had rolled out vaccination programmes and embarked upon recovery and build back better strategies amidst anticipated new coronavirus variants and preparations for a volatile pandemic-prone world.**

## **COVID-19 pandemic: from emergency response to build back better**

The COVID-19 pandemic triggered the largest global disruption in education in history. The disease control strategy included non-pharmaceutical preventive measures, such as remote and digital learning strategies across all education institutions. These strategies included what Hodges et al. (2020) called emergency remote teaching (ERT) strategies. While distance learning, remote learning, digital learning and online learning were firmly established modes of teaching and learning prior to the pandemic, they became more widely used during it. Traditional, analogue technologies such as instructional print materials (workbooks, textbooks, posters and printouts) and educational broadcasts via radio and television were harnessed alongside low-end chat platforms and higher-end broadband Internet-dependent online learning via cloud-based videoconferencing platforms (Kanwar and Daniel, 2020). Digital migration and investments were a central feature of the pandemic in almost all sectors, not only education. They included investments in digital contact tracing apps, R&D partnerships between the private sector and universities in the race for workable vaccines and large-scale digital learning roll-out programmes in response to glaring socio-economic inequalities such as the digital divide.

By October 2021, many governments had established vaccination programmes and embarked on recovery strategies, many of which were framed as ‘build back better’ strategies, as the world anticipated the arrival of new coronavirus variants and prepared for a volatile pandemic-prone world. A key feature of emerging build back better strategies was ambitious investment in climate, infrastructure and social programmes at a global level such as China’s Belt and Road Initiative (BRI) (Nedopil, 2021) and an impending G7 Build Back Better World (B3W) (White House, 2021) which will likely affect emerging national smart education investments and related national policies over the years to come.

Furthermore, amid successive waves of the COVID-19 pandemic, the OECD and World Bank (Vincent-Lancrin et al., 2022) proposed a possible international collaboration agenda and initiative on digital learning and smart education by drawing on case studies from across the world. Their framework had three pillars:

- 1 **Frontiers** (focused on ‘advanced’ practices, innovation and foresight, and how to mainstream the most effective or affordable uses of those technologies)
- 2 **Practices** (practitioner use of technologies)
- 3 **Policy** (incentives, guidelines and regulations that policy-makers can adopt)

Each of the three pillars include five types of activities to support international comparison across country contexts:

- 1 **Analysis** of stakeholder engagement to better understand technological change and their use in education
- 2 **Indicators** to help monitor the educational technology market
- 3 **Standards** to enable possible harmonization and interoperability of educational Technologies
- 4 **Capacity-development** through knowledge sharing and dissemination
- 5 **Development and evaluation** to learn from experiences in the field that can support trustworthy, human-centric development of smart educational technologies

This OECD-World Bank framework is one of several similar frameworks and toolkits that are intended to inform and guide policy-makers on ICTE and smart education policy development in a post-COVID global environment.

## Purpose of a critical analytical framework on ICTE and smart education policy

This document is aimed at education and ICTE public policy-makers, researchers and practitioners. It deliberately offers a critical framework to analyse, guide and develop emerging national government policies on smart education. It builds on ICTE policy frameworks developed over the past three decades and on emerging 4IR and AI in education (AIED) policy and strategy frameworks. Because the focus is smart education public policy, it primarily offers a high-level, macro, holistic, social systemic perspective. Therefore, it does not provide an analysis of specific emerging smart education technologies and their practical applications for learning and teaching at meso and micro levels, in classrooms and beyond. The latter have been covered extensively elsewhere. See, for example, Huang et al. (2019) and Demir (2021).

The framework’s broad scope spans existing and emerging forms of schooling, higher education, technical and vocational education and training (TVET), adult education and lifelong learning, including formal, non-formal and informal educational environments. While the discussion takes a historical view, it is also forward-looking and future-oriented and hopes to contribute to ongoing, evolving conversations and debates on appropriate smart education policy development.

## Objectives

The objectives of this critical analytical framework on smart education policy are to:

- provide a launch pad for global conversations and debate about responsible, equitable, socially just, humanistic, safe and ethical smart education policies and strategies;
- bring up the most salient smart education themes for public policy and national strategy consideration;
- situate the policy themes as responsive to problem contexts within their respective national, regional and global settings;
- highlight the tensions and contradictions within each of the themes that policy development will need to navigate; and
- consider policy implementation mechanisms to support the practice and enactment of policy as well as the feedback loops provided by ongoing evidence-based research, monitoring and evaluation.

## National smart education policies

In developing and applying a critical analytical framework, the ICTE and AI policies and strategies of ten countries were studied as specified cases of emergent smart education policies: the People's Republic of China (hereafter referred to as China), the Arab Republic of Egypt (hereafter referred to as Egypt), the Republic of India (hereafter referred to as India), the Republic of Mauritius (hereafter referred to as Mauritius), the Russian Federation (hereafter referred to as Russia), the Republic of Singapore (hereafter referred to as Singapore), the Republic of South Africa (hereafter referred to as South Africa), the Republic of Korea (hereafter referred to as South

**The framework's broad scope spans existing and emerging forms of schooling, higher education, technical and vocational education and training (TVET), adult education and lifelong learning, including formal, non-formal and informal educational environments.**

Korea), the United Kingdom of Great Britain and Northern Ireland (hereafter referred to as the UK) and the United States of America (hereafter referred to as the USA). Each of these countries has embarked on a journey towards the official adoption of formal national smart education policies that attempt to engage the rapid economic and societal diffusion of exponential technologies. While historical, socio-economic, and political contexts vary significantly across the ten countries, the similarities and differences in their policy approaches are compared critically within the parameters of the proposed analytical framework.

Table 1 provides an overview of the policies of the ten national education systems that were analysed. It shows that the ten countries vary in:

- **Population size.** China and India have populations of more than a billion people each. The USA has more than 300,000 million people, and Egypt and Russia each have over 100,000 million. The UK, South Korea and South Africa all have between 50 million and 70 million people, Singapore has more than 5 million and Mauritius has 1 million. The countries all have different economic conditions, historical contexts and experiences in policy adoption and implementation in ICTE and smart education.
- **Average national income.** This was measured by gross national income (GNI) per capita per annum in 2019. GNI per capita is widely used as one of several economic indicators to measure the size, level of development and wealth of an economy. Table 1 shows that Singapore, South Korea, the UK and the USA have a high GNI per capita of between US\$40,000 and US\$95,000; China, Russia and Mauritius rank between US\$15,000 and US\$30,000; and South Africa, India and Egypt rank between US\$6,000 and US\$13,000.
- **Human development.** This was measured by the human development index (HDI) which shows that Mauritius, Russia, Singapore, South Korea, the UK and the USA have a high HDI – between 8 and 9.5 – compared with China, Egypt and South Africa – between 7 and 8 – and India – just over 6.
- **Mean years of schooling.** This is one of many measures of the level of education in general use. Russia, South Korea, the UK and the USA have a mean of 12 years of schooling; Singapore and South Africa between 10 and 12 years; China and Egypt between 7 and 9; and India 6.5.
- **Histories and cultural contexts of ICTE policy and smart education policy adoption.** Some countries had participated in formalized policy adoption on ICTE at specified cultural-historical moments since the early 1990s. Singapore's and South Korea's formal ICTE masterplans evolved over successive five years beginning in 1996 and 1997 respectively. South Africa formalized its ICTE policy in 2004 for its basic education sector and in 2018 adopted an open learning policy that considers the integration of digital technologies in its post-school sector.

## Organisation of the report

Chapter 1 of this report presents a historical overview of ICTE, emergence of the 4IR and AI, and the recent context of the COVID-19 pandemic to set the context and emphasize the need for building resilient education systems using smart technologies. Chapter 2 provides key working definitions used in the study and the conceptual framework guiding the policy analysis and case studies. Chapter 3 presents the research methodology and describes the limitations of this study. In Chapter 4, the critical analytical framework for ICTE and smart education policies are discussed; this covers the policy elements that have emerged in the literature as well as a review of existing smart education and ICTE policies. The framework identifies policy implementation mechanisms, and these are also discussed. Examples of cases are provided with each of the policy elements and implementation mechanisms, and, importantly, gaps, tensions and contradictions are highlighted as part of the critical framing of the prominent issues. Chapter 5 presents ten country policies and fifteen case studies of smart education policy implementation in the study countries. Based on the review, policy analysis and the case studies, Section 6 concludes with a summary of the reviews and the case studies, a proposed draft policy template and a policy implementation monitoring framework.

**Table 1. Selected country ICTE and smart education policies and strategies**

Country	Population (2022)	Historical ICTE policies	Recent smart education policies	GNI per capita 2021 (Atlas method)	HDI (2022)	Mean years of schooling (2019)
<b>China</b>	1 448 471 400	Ten-Year Development Plan on ICT in Education 2011-2020 (2012) 13th Five-Year Plan for ICT in Education (2016) Education Informatization 2.0 Action Plan (2018)	Education Modernisation Plan towards 2035 Next Generation AI Development Plan	\$11 890	0.758	8.1
<b>Egypt</b>	106 156 692	Egypt ICT Strategy 2007-2010 Egypt ICT Strategy 2013-2017	Egypt National AI Strategy (2021)	\$12 910	0.7	7.4
<b>India</b>	1 406 631 776	National Policy on Information and Communication Technology (ICT) In School Education (2012)	National Education Policy 2020 National Strategy for AI (2019)	\$7 220	0.645	6.5
<b>Mauritius</b>	1 274 727	National ICT Strategic Plan 2011 – 2014: Towards i-Mauritius National ICT Policy 2007-11 ICT Strategy for the Mauritius's Education Sector presented by Education Minister National Open Data Policy 2017	Digital Mauritius 2030 Strategic Plan Digital Government Transformation Strategy 2018 - 2022 Mauritius Artificial Intelligence Strategy 2018	\$25 530	0.796	9.5
<b>Russia</b>	145 805 947	Strategy of Development of Education in the Russian Federation for the Period Until 2025 (2015)	The Digital Transformation National Goal (2018)	\$11 600	0.824	12.2
<b>Singapore</b>	5 943 546	ICT Masterplan I (1997-2002) ICT Masterplan II (2003-2008) ICT Masterplan III (2009-2014) ICT Masterplan IV (2015-2020)	Smart Nation Strategy (2018) AI Singapore	\$64 010	0.935	11.6
<b>South Africa</b>	60 756 135	e-Education White Paper (2004) Open Learning Policy (2018)	Ministerial Task Team on the Fourth Industrial Revolution and Post Schooling Education (2020)	\$6 440	0.705	10.2
<b>South Korea</b>	51 329 899	Masterplan I (1996) Masterplan II (2001) Masterplan III (2006)	Masterplan IV (2010): Smart Education Masterplan V (2014): Student Centred Learning	\$34 980	0.906	12.2
<b>UK</b>	68 497 407	Realising the Potential of Technology in Education: A Strategy for Education Providers and the Technology Industry (2019)	National AI Strategy (2021) Scotland's Artificial Intelligence Strategy. Trustworthy, Ethical and Inclusive	\$45 380	0.92	13.2
<b>USA</b>	334 805 269	National Education Technology Plan (2017) National Education Technology Plan Higher Education (2017)	Updating National Education Technology Plan for 2021	\$70 430	0.92	13.4

Sources: World Population Review (2021); World Bank (2021).

A photograph of two female students in a laboratory or classroom setting. The student in the foreground, wearing a blue and white striped sleeveless shirt, is smiling and looking towards the right. The student in the background, wearing a white t-shirt with a cartoon character, is also smiling and looking down at a device on the table. The device is a small, white, cylindrical robot with a black top and bottom, and several colored wires (yellow, blue, red) extending from the bottom. The student in the background is holding a black probe or sensor and is adjusting it on the top of the robot. The background shows a blue wall and some laboratory equipment.

## Chapter 2

### Conceptual framework

## Conceptual framework

The smart education critical analytical framework is guided by the following operational definitions and concepts. However, during its development the authors were mindful of a spectrum of competing theories and methodologies in comparative policy analysis described in this chapter.



**Socio-technical imaginaries:** The critical analytical framework is informed by the concept of a socio-technical imaginary as propounded by Jassanoff and Kim (2009, 2015). Sociotechnical imaginaries are imagined forms of social order that centre on innovative scientific and technological projects. They are formed through socially and publicly performed discourses of desirable future societies, and through inscriptions and the materiality of technology. This concept enables a discussion of technologies and their influence on society and education and recognizes that there are emerging alternatives being proposed by the likes of UNESCO in the form of calls for a new social contract for education where pedagogies are rooted in co-operation and solidarity (UNESCO, 2021a).

**Critical policy analysis:** This framework adopts a conceptual foundation based on the view that policy is a space of contestation and tension in relation to policy influences, the way policy texts are produced, the way policy is enacted and practised and the trajectories that policy invariably assumes over time. Drawing on a policy sociology and critical analysis, the current framework acknowledges more explicitly than previous frameworks that many of the issues that relate to ICTE and smart education policy are contested and that there are competing theories, frameworks, interpretations, analyses, methodologies, practices, ideas and policy pathways. It also acknowledges that there are dominant worldviews and narratives that interface with perspectives that also challenge hegemonic policy discourses. In adopting a critical analytical stance, this framework therefore:

- applies the word ‘critical’ not as a reference to negative thinking or deliberate negative comments, but as a basis for surfacing complexities, controversies, contradictions, inequalities, power asymmetries and relations that have come to define the ICTE and smart education policy, practice and research landscape. The framework clarifies policy concepts, approaches and practices in ICTE and smart education policy texts across the ten countries and highlights gaps, missing links and contradictions across each of the key pillars and implementation mechanisms that broadly define the framework parameters. The intention is to encourage more robust stakeholder engagement on the complexities of smart education policy decision-making and action-taking.
- facilitates discussion and debate in recognition of multiple, often contending, perspectives, viewpoints and knowledges and intentionally poses questions that bring up new and alternative approaches alongside existing, dominant mainstream views. For instance, alongside the positive, sometimes technological solutionist narratives about how educational technologies can transform education, we also need to look at how educational technologies can perpetuate and create new forms of inequalities.
- challenges simplistic assumptions about the inevitability of smart technology adoption in education and that these technologies are inherently neutral or benevolent (Carrim, 2020) or that their adoption follows a linear trajectory towards emulating ‘developed’ economies.
- acknowledges the value of interdisciplinary/transdisciplinary approaches by transcending the predominance of STEM disciplines in ICTE policy decision-making by including insights from a range of disciplines – including the humanities, social sciences and policy-making – into how smart technologies are also socially constructed, embedded and embodied.
- recognizes an emerging post-digital (Knox, 2019) shift in the global educational technology discourse that highlights critical perspectives on the changing relationship among technologies, being human, humanism and education.

**Educational technologies:** For the purposes of this document, the term ‘educational technologies’ refers to the existing and emerging technologies that are increasingly integrated, embedded and embodied in learning systems with the purpose of opening up new vistas for learning, teaching, education management, governance and administration in a variety of instructional settings and contexts, including in formal, informal, non-formal, lifelong learning,

learning-on-demand and just-in-time learning settings. Educational technologies have evolved from audiovisual aids to individual and networked computers, and increasingly include various mobile and smart technologies, as well as virtual and augmented realities, avatar-based immersive environments, cloud computing, and wearable and location-aware devices. They also include technologies that enhance learning and instruction as espoused by Huang et al. (2019).

**Educational technology systems:** This references the widening expanse of networked human and non-human actors, organizations and institutions (public, private or multisector), material and technical forms (hardware, software, supporting documents), modes of practice (of teachers, designers, policy-makers) and framing discourses. It is also a highly varied field of research, development and critical inquiry (Knox, 2020).

**Educational technologies have evolved from early uses of audio-visual aids to individual and networked computers, and are increasingly including various mobile and smart technologies, as well as virtual and augmented realities, avatar-based immersive environments, cloud computing, and wearable and location-aware devices.**

**Learning lessons from past ICTE policy, practice evidence and experience:** To date, many countries across the world have had significant experience with ICTE policy adoption and implementation. This experience has expanded the global evidence base. Some countries, such as Singapore and South Korea, have had successive country policies and masterplans on ICTE. This framework draws on these experiences and various global guiding frameworks to analyse and inform public policy development on the complexities of emerging smart education.

Many ICTE policies and related large-scale educational technology interventions have not had the systemic equitable transformational effects that were imagined when they were designed (Reich, 2020). The reasons for these vary from country to country but also present generic lessons:

- **Policy design:** Policy prescriptions were not premised on active citizen and multistakeholder participation and shared policy ownership, which points to the need for more inclusive policy development approaches.
- **Policy implementation:** Many policies were not accompanied by the requisite change in leadership, political will, organizational capacity or resources to realize national policy objectives. Where they included masterplans for implementation, these have not always been implemented as planned, and were often accompanied by inadequate resourcing models.
- **Continuous system learning:** Many policies have not integrated research or monitoring and evaluation to enable evidence-based policy development and ongoing system and institutional learning by system stakeholders.
- **Formal public ICTE and smart education policy as a unit of analysis:** While the term is sometimes used interchangeably with ICT in education (ICTE) policy, smart education policy is a messy, complex, contradictory process geared towards producing national public policy responses to the influences of exponential technologies in education systems and the influence of these technologies on the datafication of the education

policy process itself. Jarke and Breiter (2019) explain that the datafication of education involves the systematic collection of data from all levels of the education system, and potentially covers all teaching, learning, school management processes to enable data-driven diagnoses, prediction and decision-making by education stakeholders, including policy-makers and EdTech companies.

For the purposes of this framework, formal government policy texts and policy implementation processes on ICTE and smart education serve as the unit of analysis. Here public policy is conceptualized as a national state-led complex, networked, institutionalized apparatus through which the integration of emerging educational technologies is governed, managed, used and produced to achieve national educational goals. In this sense, as Mishra (2020) suggests, policy includes executive decision-making, legislation and national strategies designed and approved by governments and supported by institutionalized policy networks. The OECD (2018) adds that new scientific knowledge from the psychology, neuroscience, biomedicine, computer science, machine learning and software engineering sectors also influences education policy formation, which would additionally fall within the realm of smart education policy.

**Smart education:** There is currently no shared understanding of what smart education is, which suggests that it is still a fluid, dynamic and contested concept that assumes different meanings in different spatiotemporal institutional and national contexts. The complexity of the concept makes developing policy on smart education challenging. ‘Education’ here refers to public, institutionalized national systems of education governance, and includes the governance of private education institutions.

Smart education is a widely used reference to the exponential growth and diffusion of data-intensive, algorithmic exponential technologies in economies and society and their growing catalytic influence on education and training systems both nationally and globally. Exponential technologies include AI, virtual reality (VR), augmented reality (AR), the Internet of Things (IoT),

**Smart education is a widely used reference to the exponential growth and diffusion of data-intensive, algorithmic exponential technologies in economy and society and their growing catalytic influence on education and training systems nationally and globally.**

big data, blockchain, 3D printing and wearable technologies, all of which are already redefining relationships between humans and machines. Many definitions of smart education focus on the powerful and influential ways in which these technologies open new vistas for learning (such as personalized learning anytime, anywhere), teaching and education management (Bajaj and Sharma 2018; Pedró et al., 2019) and on their potential for catalysing education transformation. In this respect, this framework also engages with Huang’s (2014) definition of smart education as a system of educational behaviours characterized by heightened learning experiences, continuous learning content adaptation and teaching efficiency. Smart education is thus associated with the adoption of modern science and technologies to provide diversified support and on-demand services for students, teachers and parents, while the data of participants and learning and teaching processes are recorded and used to promote the quality and equity of education.

According to Kanwar (2021), smart education must focus on being:

- enjoyable, leading to the retention and transfer of knowledge to long-term memory;
- engaging, with innovative application of technologies;
- efficient, in terms of just-in-time learning and availability for right resources;
- effective, in leading to the earning livelihoods and development of responsible citizenship; and
- ethical, to address issues of privacy, cybersecurity and equity.

Thus, smart education entails a philosophical approach as well as the use of advanced technologies to improve the quality of teaching and learning. Such uses also have to take into consideration the dangers to safety and well-being of children and youth.

# Chapter 3

## Methodology



## Methodology

A qualitative research methodology was applied to develop a critical analytical framework on smart education policy. It included case study methodology applied to ten selected national and related supranational policy texts on ICTE and smart education policy and fifteen case studies of selected policy-informed implementation projects. A systematic literature review was supported by comparative policy discourse analysis.



## Systematic literature review

The aim of the systematic literature review (SLR) was to identify

- the most salient analyses on ICTE policies, particularly public policies on smart education;
- critical reflections on and analyses of ICTE and emerging smart education policies; and
- ten countries in which to analyse the most salient and critical aspects of ICTE and smart education policies.

The SLR was based on an overarching research question (Xiao and Watson, 2019): What were the design, implementation and outcomes of ICTE policies across selected countries across the world and what are the design features of emerging smart education public policies?

The more recent Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) protocol was followed (see Figure 1) and Mendeley was used for reference and bibliographic management.

### Identification

The review used the following general search terms:

- 'ICT in Education' and Policy
- 'ICT in Education' and Master Plan
- 'Digital Education' and Policy
- 'Digital Transformation in Education'
- 'Digital Education Action Plan'
- 'Smart Education' and Policy
- 'Smart Learning' and Policy
- 'AI in Education' and Policy

The databases consulted were Scopus, Web of Science, Google Scholar and Mendeley. Together these cover a wide range of social science publications: journals, eBooks, book chapters and conference proceedings, theses, generic papers, reports, working papers, web pages and magazine articles.

Several search restrictions were applied to limit the number of irrelevant results. The requirements for the purposes of this analytical framework were that publications were published:

1. in the English language;
2. as peer-reviewed academic journals, book chapters or conference papers; and
3. between 1996 and 2021. The time span was chosen in recognition of successive waves of ICT4E policy development over time for many countries (Hinostroza, 2018).

The results per database are shown in Table 2. Relevant publications were selected to guide the development of an analytical framework.

**Table 2. Search term results per database**

Search Term	Google Scholar (1996-2021)	Scopus (1996-2021)	Mendeley (2012-2021)	Web of Science (1996-2021)
'ICT in Education' and Policy	18 600	193	4 940	120
'ICT in Education' and Master Plan	13 500	8	77	1
'Digital Education' and Policy	16 000	91	8 684	82
'Digital Transformation in Education'	1 070	16	9 592	4
'Digital Education Action Plan'	1 050	7	847	4
'Smart Education' and Policy	7 150	27	2 719	27
'Smart Learning' and Policy	6 550	21	3 021	20
'AI in Education' and Policy	1 470	11	543	4
<b>TOTALS</b>	65 390	374	30 423	262

### Screening

From the results, the following records were excluded:

- those that focused on ICTE and the use of specified educational technologies in various education sectors and institutions;
- those that focused on smart technologies and smart learning only, without considering policy implications;
- those that focused on the use of smart technologies in sectors outside of education;
- those that did not relate directly to education issues – for instance, Web of Science provided a further breakdown of Web of Science categories of the results and here only the education and education research categories were considered;
- those that spoke to transversal policies on smart cities and smart transport systems; and
- those that referred more to institutional policies and not national public policy in education.

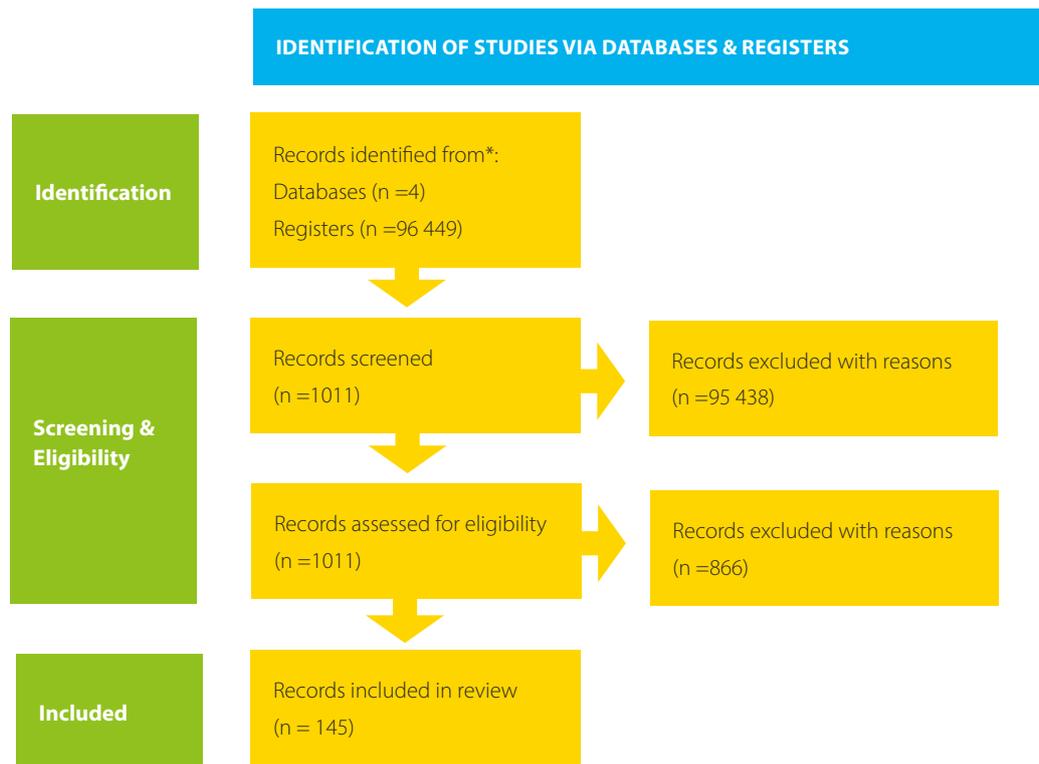
### Eligibility

Following these exclusions, records that were included were those that

- analysed global, regional and national policies, strategies and masterplans related to ICTE, smart education, AI and education and had specific themes related to ICTE policies;
- focused on national ICTE, AI, smart learning and smart education policies in the selected countries;
- analysed smart education, ICTE, remote learning and digital learning strategies during the COVID-19 pandemic; and
- offered critiques of and debates on ICTE and smart education policy issues.

### Included

A total of 145 records were included in the final sample: 32 national policies; 44 global and regional policy guidelines and frameworks; and 69 journal articles, reports, books and book chapters.



**Figure 1: PRISMA protocol applied to systematic review**

## Case study methodology and comparative policy discourse analysis

We also adopted a case study methodology, drawing on Yin (2014), who defines the case study as ‘an empirical inquiry that investigates a contemporary phenomenon (the case) in depth and within its real-world context’ (p. 16). The case studies chosen for this framework serve as illustrations of historical, existing and emerging ICTE and smart education policies across the world. They represent specific cases of contextually informed design and application of ICTE and emerging smart education policy and practice over time. The ten country case study policies were selected from ten selected countries based on the following criteria:

- 1.** The country has developed or is engaged in developing national public policy and strategies on ICTE and smart education or smart learning.
- 2.** The country has national policies and strategies that have or are introducing smart education or smart learning initiatives.
- 3.** The country has established institutional structures to design, govern and manage ICTE and smart education and smart learning initiatives at a national level.

Alongside and as part of the case study methodology, the more recent policies related to smart education and ICTE per country were reviewed using comparative policy discourse analysis that incorporates content analysis (Prior, 2020) and critical policy discourse analysis (Mulderigg et al., 2019). Mulderigg explores how the constitution, contestations, tensions and transformation issues are articulated in the policy process, policy engagements and policy texts. Critical policy discourse analysis also attempts to clarify policy processes beyond their apparent inputs and outputs by addressing the values and normative assumptions that shape policy. The methodology also includes a comparative analysis of smart education policies across the ten case study policies through the use of the critical analytical framework.

**The case studies chosen for this framework, serve as illustrations of historical, existing, and emerging ICTE and smart education policies across the world.**

We also present fifteen case studies of illustrative policy-linked smart education initiatives across the ten countries. The criteria for the selection of these smart education initiative case studies were:

1. National or state-level flagship ICTE or smart education initiatives were in place.
2. Smart education practices could be seen at country or state level.
3. ICTE or smart education initiatives had been designed to promote various aspects of the Sustainable Development Goals, particularly Goal 4, 'Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all'.

### **Limitations**

The research methodology relied primarily on secondary sources and sought to verify data from academic and grey literature particularly where evidence-based research was available. The project was also limited because of time constraints, which prevented us from exploring further possibilities for triangulation via primary information sources such as interviews with policy-makers from each of the case study countries and case study initiatives. Nevertheless, the critical analytical framework provides a robust tool for understanding, designing and implementing emerging smart education policies and practices and fostering further debate and discussion.

## Chapter 4

# A critical smart education policy framework



## A critical smart education policy framework

The framework situates smart education policy in context by looking at the ways in which historical, cultural, socio-economic, political and environmental factors shaped and influenced the design of smart education policy, the formulation of policy texts, the discourses that accompany policy enactment and the pathways and trajectories that policy-informed practice assumes. The framework uses and combines a range of interrelated concepts, in the same way as they appear in existing policy texts on ICTE and smart education for purposes of comparative analysis.



The framework is centred on an analysis of contextual influences, the formulation of policy texts, the enactment of policy in the form of institutional structures and specified projects and those projects' possible accompanying policy trajectories. It identifies the way national public ICTE and smart education policies articulate a shared vision that serves as an aspirational guiding frame. It also highlights the way in which key principles and values are informed by the formulation of policy rationale and the framing of problems that policies were designed to address. The critical analytical framework further identifies six interrelated salient themes that have emerged consistently across all policies as well as three themes related to the practice and enactment of policy, which the framework refers to as implementation mechanisms. Figure 2 provides a snapshot of the framework and its interrelated smart education themes.



Figure 2: A critical analytical framework for smart education policy

The six inter-related policy themes are:

1. Infrastructure;
2. Curriculum and pedagogy;
3. Digital education resources;
4. Skills and competencies;
5. Governance;
6. Management and administration.

Each of these themes include key sub-themes as shown in Figure 2.

The framework also identifies three salient policy implementation mechanisms:

1. Leadership, system capacity and change management;
2. Finance, funding and resource mobilisation and partnerships;
3. Monitoring, evaluation, research, and innovation.

Each of the 10 smart education policies reflect context-specific illustrations of their policy influences, policy adoption and institutionalisation processes and each are at different transitional moments and trajectories with varying expressions of systemic tensions as they relate to the six identifiable policy themes and policy implementation mechanisms. The latter is a deliberate acknowledgement of the fluidity, complexity, and dialectical nature of policy processes and that they are invariably filled with tensions and gaps within each of the policy themes and enabling implementation mechanisms. As part of the comparative policy discourse analysis methodology the most salient high-level tensions and gaps are identified per theme and implementation mechanism.

## Five levels of smart education policies and strategy adoption

With intensifying, powerful, global digitalisation and datafication, a few regions and countries have evolved from its ICTE paradigm towards the embrace of an emergent and increasingly pervasive 4IR discourse. In this respect, this study has identified five types of smart education policies:

1. **Global smart education and AI in education frameworks** have been adopted in consultation with national governments, academics and consultants. They include the Beijing Consensus on AI and Education (UNESCO, 2019a), the OECD's Trustworthy AI in Education (Vincent-Lancrin and Van der Vlies, 2020), UNESCO's AI and Education. Guidance for Policy-makers (Miao et al., 2021), UNICEF's Policy Guidance on AI for Children (UNICEF, 2020), OECD Digital Outlook 2021: Pushing the Frontiers with AI, Blockchain and Robots (OECD, 2021) and more recently UNESCO's (2022b) AI K-12 Curricula Mapping of Government-endorsed AI Curricula, which rank among the most important policy-related guiding frameworks.
2. At a **geopolitical regional level**, some regions have developed regional transversal frameworks. They include smart city frameworks, which embed concepts of smart education, such as the ASEAN Smart Cities Framework (ASEAN, 2018), to form a regional smart city network.

**While a few countries have taken the lead by formally adopting smart education policies and strategies, many are still in the process of formalizing their national public plans and strategies on smart education and others have only recently adopted national ICTE policies.**

3. At a **national transversal level**, national artificial intelligence strategies and plans for smart government, smart economies and smart cities in which smart education policies and strategies are entrenched. China, Egypt, India, Mauritius, Singapore and the UK are among the early adopters of national AI strategies within which education and training strategies for skills and talent development, curriculum change and research feature prominently. At the time of writing in early 2022, Russia, the USA and Korea were developing national AI strategies, and South Africa had already established a presidential commission on 4IR. This document reviews the educational commitments in these transversal national policies and strategies in ten countries. Dutton (2018) and Smuha (2021) suggest that there is a race to develop appropriate regulatory and legal frameworks that are responsive to changes in AI systems and subsequently assumes global dominance in a growing AI world.
4. Dedicated national smart learning policies and strategies, as in Korea and Mauritius.
5. National **ministerial task team reports in preparation for smart education policy and strategy development**, such as South Africa's Ministerial Task Team (MTT) on the Implications of the Fourth Industrial Revolution (4IR) for the Post-School Education and Training System (PSET).

## Varying adoption and implementation stages

This critical analytical framework acknowledges that at a macro-level, the policy and strategy development space is fluid. While a few countries have taken the lead by formally adopting smart education policies and strategies, many are still in the process of formalizing their national public plans and strategies on smart education and others have only recently adopted national ICTE policies. The framework also acknowledges the influences of the global geopolitical landscape on the adoption and development of smart education policies and strategies. These include the reality that some countries wield more powerful global, regional and national influence than others; and some are significantly larger in terms of geographical expanse, population size and economic size compared to small island development states (SIDS).

## Policy context matters

The framework starts with situating smart education public policy formation beyond the technologies and within the particular contexts and complexities of national education systems. The centrality of national contextual factors in education policy development has re-emerged because of the limitations of borrowing ready-made policies from 'best-performing' education systems without taking into account local contextual differences (Harris and Jones, 2018). Such differences are also an issue in the ICTE policy space, and often policy borrowing disregards the peculiarities of local and national contexts. Looking at the ten case study systems, it is apparent that the size of the education system and how the size influences the design and implementation of policy are important contextual factors. The interrelationships and intersections of historical, cultural, socio-economic, political and environmental influences on



national education and training systems are also pivotal to policy framing (Pelletier et al., 2021; Zhang, 2007). The approach described above is also informed by theoretical frameworks that suggest that technologies, their design, production, consumption and distribution are socially constructed in context (Toyama, 2015).

## Historical context

The influence of historical factors can be seen in the ICTE policy development experience outlined in the ten country case studies. ICTE and smart education policies build on and are outcomes of evolution and struggles within broader national change processes over time. China, Russia and South Africa offer good examples of education systems that have transitioned from one economic and societal system to another. For example, the fact that many schools, colleges and universities in historically disadvantaged communities in South Africa remain significantly under-resourced in terms of ICT infrastructure access and digital learning is attributed to, among other things, the legacy of South Africa's apartheid education system (Chisholm, 2012; Isaacs, 2020). Adopting a historical perspective allows us to place current and emerging smart education policy within the context of past innovations, challenges and struggles. In Singapore and South Korea, successive five-year ICTE masterplans, which relate integrally to their respective political histories, have been adopted since 1997. This suggests that emerging smart education policy will need to be situated within cultural, political and historical analyses of policy lessons, evidence and experience in these countries (Kang and Yoon, 2020; Toh and Looi, 2020).

Thus, when comparing the ten countries and their ICTE and smart education policy experiences, note that China, India, Russia, Singapore and South Korea, for example, have a longer timeline and experience with policy formation compared to South Africa and Mauritius. Table 3 provides a timeline comparison across the ten countries that takes into account the countries' respective histories.

**Table 3. Comparing ICTE and smart education policy development across the ten countries over time**

Timeline	Comparing the ten countries' ICTE policies over time
<b>1980s</b>	<p><b>China:</b> Policies on technologies in education were not yet developed, although the use of technologies in education was prevalent and was referred to as 'electrifying education' (or audiovisual education.). China drafted policy plans on electrifying education in 1978 and began to popularize computer education in 1984.</p> <p><b>Egypt:</b> Policies on technologies in education were not yet developed.</p> <p><b>India:</b> India's national educational policy of 1986 highlighted the need to use educational technology (ET) to improve access, quality and governance of education.</p> <p><b>Mauritius:</b> The Mauritian government began investing significantly in improving its national education system in the 1980s, although no explicit policies were made on the integration and use of educational technologies at the time.</p> <p><b>Russia:</b> Formal adoption of computers in education in the then Soviet Union included the introduction of computer science as a subject and the promotion of computer infrastructure in education institutions.</p> <p><b>Singapore:</b> Did not have an explicit educational technologies policy in the 1980s.</p> <p><b>South Africa:</b> Computers in schools initiatives emerged as part of the anti-apartheid movement.</p> <p><b>South Korea:</b> Embarked on a high-tech industrial strategy that laid the foundation for the development of ICT in education masterplans in the 1990s.</p> <p><b>UK:</b> The UK's Department of Trade and Industry (DTI) provided funds to support schools in the 1980s to acquire newly developing technologies. In 1985, the DTI provided £1 million in funds to provide a modem for every school, and in 1988, a grant of £140 for each secondary school to install a telephone line for data communication (Passey, 2014).</p> <p><b>USA:</b> Had not yet adopted an official policy on the use of educational technologies.</p>
<b>1990s</b>	<p><b>China:</b> Adopted a policy on strengthening computer education in primary and secondary schools (Alamin et al., 2015) in 1992, and launched its Five-Year Development Program of School Computer Education (1996–2000) in 1996.</p> <p><b>Egypt:</b> In the early 1990s, some government institutions led various initiatives to access computers in schools, although no formal policy adoption was in place.</p> <p><b>India:</b> The national education policy was updated in 1992 and included commitments to introducing educational technologies and led to two flagship schemes: Educational Technologies ET and Computer Literacy and Studies in Schools (CLASS).</p> <p><b>Mauritius:</b> Its 1997 masterplan in education committed to enhancing technical subjects, although there were no explicit references to ICT.</p> <p><b>Russia:</b> There was a shift from the Soviet ideological and centralized administrative model to the development and experimentation of curricular ideas and teaching approaches drawing on international models.</p> <p><b>Singapore:</b> Introduced its first five-year ICTE masterplan in 1997 as part of a concerted economic modernization programme.</p> <p><b>South Africa:</b> Shifted from an apartheid-based ideological and legal education model towards an egalitarian education system. The Department of Education launched its Technology-enhanced Learning Initiative (TELI) in 1995.</p> <p><b>South Korea:</b> Introduced its first five-year ICTE masterplan as integral to its national strategy to grow a high-tech economy in the aftermath of military rule and at the dawn of a democratic state.</p> <p><b>UK:</b> Formalized a national curriculum policy in 1990 that integrated technologies in the national curriculum. Teachers no longer had the choice between using computers or not. Each student was entitled to a curriculum that included information technologies (Passey, 2014).</p> <p><b>USA:</b> In 1991, USA launched the National Information Infrastructure (NII), which was a basic step towards the widespread use of ICT in education in the USA. In 1996, it adopted its first national educational technology plan, Getting America Students Ready for the 21st Century.</p>

<p><b>Early 2000s</b></p>	<p><b>China:</b> Developed a series of policies in the early 2000s, including its National Tenth Five-Year Plan of Education (2001); Tenth Five-Year Plan for Educational Technology (2002); 2003–2007 Action Plan for Invigorating Education (2004), 2006–2020 National ICT Development Strategy (2006) and Eleventh Five-Year Plan for National Education Development (2007).</p> <p><b>Egypt:</b> In 2008, the Egyptian Ministry of Communication and Information Technology (MCIT) established plans for the infrastructure required for enhancing e-learning, including providing universities with high-speed Internet networks, establishing videoconference links at all universities, establishing e-content development labs in each university to help staff produce e-learning materials, training both staff and administrators in the efficient use of information technology, and inviting both international and local experts to review the current capabilities and technical materials for e-learning (MCIT, 2012).</p> <p><b>India:</b> Adopted an ICT in schools policy in 2004 which was further developed in its 2005 National Curriculum Framework which recommended the optimal use of ICT in education (Mahashevt, 2017).</p> <p><b>Mauritius:</b> Adopted a national ICT policy for 2007–2011 that included guidelines for the education and training system.</p> <p><b>Russia:</b> In 2000, there was nationwide construction of new institutional mechanisms in education, including per capita financing, public engagement, quality assurance (e.g. a national school leaving exam), modernization of school infrastructure and greater student choice.</p> <p><b>Singapore:</b> Learned from its first five-year ICTE masterplan and embarked on its second five-year masterplan as part of a national strategy to become a leading, globally competitive education system.</p> <p><b>South Africa:</b> In 2004, the post-apartheid government formally adopted the e-Education White Paper with equity and social justice underpinnings.</p> <p><b>South Korea:</b> Developed its second masterplan, Adapting ICT into Education Master Plan II, which focused on promoting the use of e-learning in classrooms to improve creativity and problem-solving skills.</p> <p><b>UK:</b> From 2004, spending on infrastructure under the Building Schools for the Future initiative put technology centre stage in the schooling system in the UK.</p> <p><b>USA:</b> Adopted its second NETP in 2000, Putting a World-class Education at the Fingertips of all Children, and its third in January 2005, Toward A New Golden Age in American Education.</p>
<p><b>Early 2010s</b></p>	<p><b>China:</b> Adopted its Educational Technology Plan 2011–2020 during this period.</p> <p><b>Egypt:</b> Developed an ICT strategy for 2013–2017, which included guidelines for ICT application in the Egyptian education system as part of a concerted strategy to engage in a globally competitive world economy.</p> <p><b>India:</b> Adopted its National Policy on Information and Communication Technology (ICT) in School Education (2012).</p> <p><b>Mauritius:</b> Adopted its National ICT Strategic Plan 2011–2014: Towards i-Mauritius.</p> <p><b>Russia:</b> In 2012, the national education system achieved global competitiveness in education while assuring the equality of educational opportunities by raising the status of teachers (including significant salary increases), continuing to develop quality control mechanisms and introducing new curricular standards. In 2016, the national curriculum policy returned to centralized public ownership and management. In addition, the idea of a 'common education space for all schools' was promoted. The federal education standards were revised to reduce the curricular autonomy of schools and teachers (Froumin and Remorenko, 2020).</p> <p><b>South Africa:</b> Adopted a national ICT policy and post-school policy in 2014, both of which were influenced by underlying global competitive discourse.</p> <p><b>Singapore:</b> Launched its third ICT in Education Master Plan (2009–2014) and then its fourth Master Plan (2015–2020).</p> <p><b>South Korea:</b> Developed its fourth masterplan, Master Plan 2010 on Smart Education, followed by a fifth in 2014 which focused on student centred learning.</p> <p><b>UK:</b> Engaged stakeholders in developing a national strategy and in 2019 adopted Realising the Potential of technology in Education: A Strategy for Education Providers and the Technology Industry.</p> <p><b>USA:</b> In 2010 it adopted its fourth NETP, The Model of Learning Powered by Technology–Transforming American Education.</p>

Sources: Froumin and Remorenko (2020); Isaacs (2020).

When situated in historical context, Singapore's successive five-year ICTE masterplans since 1997 need to be viewed against the backdrop of the country's emergence as an independent state in 1965, following state control by Japan, the UK and Malaysia, respectively. In the 1960s and 1970s, Singapore embarked on a concerted economic modernization programme to establish a manufacturing industry, develop large public housing estates and invest heavily in public education and infrastructure, and develop a national system of innovation. Key to Singapore's national strategy has been its positioning of itself as a leading, learning, smart nation within a globally competitive economic and labour market.

South Korea's successive five-year masterplans on ICTE dates to the early 1980s, when the country's industrial strategy focused on the growth of high-tech and computer industries. This coincided with the country's shift away from military rule towards a democracy in 1993.

The UK's AI strategy needs to be viewed against the backdrop of its historical role as a dominant colonial empire. Its strategy reflects its long and exceptional history in AI, from the work of Alan Turing, one of the founders of AI and a leader in his field, to more recent pioneering inventions. The UK ranks third-highest in the world for private investment in AI, and it positions its 2021 AI strategy as the next step in its AI journey.

## Cultural context

A smart education policy needs to be responsive not only to local education system cultures and the diversity of cultures within a given country, but also to how cultures shape and influence technological design and adoption and how technologies are changing and shaping cultures. Zhang (2007) demonstrates how Eastern cultures and philosophies have influenced the structure and design of education systems in countries like China, South Korea, Singapore, Japan and Thailand, and how this influenced their ICTE policies and masterplans. India's policy states explicitly that it envisages an education system rooted in Indian culture. Egypt's national AI strategy identifies the cultural challenges posed by AI with its recognition of concerns about the potential loss of nuances in culture and language that can be caused by the use of natural language processing (NLP) systems.

Thus, in addition to the pressures of global changes, smart education policy development is also influenced by the complex interplay between global and local cultures.

## Socio-economic and political context

Smart education policy reflects and responds to the political conditions and history of a country. In recent years, education policies, including ICTE and smart education policies, have been associated with shifts in the political ideology of a country. For instance, in Russia and China in the 1990s, there was a shift towards market-oriented policies, and more recently, education policies have been shifting towards being state-driven and state-led (Piattoeva and Gurova, 2021). In Singapore, South Korea and South Africa, for example, the adoption of technology-related policies, including ICTE, accompanied a political shift from regimes under occupation or military control towards democratic states.

The socio-economic conditions of each of the ten case study countries were linked to the capabilities of the state and its aspirations for improving access to, quality and equity in education and human development. For the purposes of comparison, this framework drew on a range of human development indicators to provide a snapshot of a country's human development, levels of inequality and socio-economic status, but recognized ongoing debate about their limitations (Hickel, 2017). Key among these were the Human Development Index by country (United Nations Development Programme, 2020), the Country Inequality Index (World Inequality Lab, 2020), a gender inequality index (United Nations Development Programme, 2020) and the per capita gross national income and Human Capital Index (Corral et al., 2021), Table 1 provides a snapshot of some of the key indicators of the socio-economic conditions of each of the ten countries for comparison.

## Influence of the growing global EdTech market and meta-EdTech

A smart education policy also needs to be responsive to the increasing influence of the growing global EdTech marketization of national education and training systems. This manifests as growth in commercial EdTech products that are used by national governments, ministries of education, education institutions and private consumers (parents, teachers and learners). The range of EdTech products produced by global multinationals is growing in tandem with the growth of EdTech start-up companies and their venture capital networks locally and worldwide. In 2020, the global education technology market was valued at US\$89.49 billion and was projected to experience a compound annual growth rate (CAGR) of 19.9% from 2021 to 2028 (Grandview Research, 2021).

In each of the ten case study countries, the growth of the EdTech market reflects the global trend. For example:

- According to a broader market definition, the online education market in China was estimated at 346.8 billion yuan (approximately US\$2,312 billion) in 2019 and 423 billion yuan (approximately US\$2,820 billion) in 2020. It is projected to reach 490.5 billion yuan (approximately US\$3,270 billion) by 2030 (Textor, 2021).
- South Africa had an estimated 292 EdTech start-up companies in 2022 (Tracxn, 2022) and it is anticipated that the revenue of South Africa's e-learning industry will grow at an estimated CAGR of over 12% during the period 2018–2023 (Research and Markets, 2019).
- The 2022 market valuation of the Indian EdTech industry was estimated at US\$2.8 billion and is expected to reach US\$10.4 billion by 2025. In 2022, India had 9,043 EdTech start-ups (Bhardwaj, 2022).
- The Singapore e-learning market was valued at US\$792.97 million in 2019 and is expected to reach US\$2,228.74 million by 2027; it is estimated to grow at a CAGR of 13.6% during 2020–2027 (Insight Partners, 2020). The US e-learning market is estimated to grow by US\$36.54 billion during 2021–2025, progressing at a CAGR of almost 17% (Research and Markets, 2021)

Williamson (2021) suggests that the nature and extent of EdTech growth is such that, as a category, it is expanding in scope and scale; involving an increasing variety of actors (human and non-human), organizations, material and technical forms (hardware, software and supporting documents), and modes of practice; framing discourses; and emerging as a varied field of research, development and critical inquiry.

Policy responses to the growth of the EdTech market have ranged from curtailing the influence of global EdTech multinationals – as in China – to providing conditions for institutionalizing EdTech start-ups and the use of commercialized EdTech products – as in Singapore.

The recent literature also considers the status of a country's industrial sector in terms of its 'readiness' for and transition towards a fourth industrial revolution (4IR) as a smart education policy imperative. The WEF has introduced a country-specific 4IR archetype analysis based on the structure of production in relationship to the drivers of production. The resulting matrix is then characterized within four system archetypes: Global Leaders, Followers, High Potential and Legacy Champions. Multinational consultancies like Deloitte have also developed an Industry 4.0 Index, which maps the status of countries across the world. Notably, many of the available indicators and schemas are applied widely for the purposes of global comparison, but their reliability is also widely disputed (Khoo, 2011).

**A smart education policy also needs to be responsive to the increasing influence of the growing global EdTech marketization of national education and training systems.**

## Environmental context

Pelletier et al. (2021) look at the environmental context within which educational technology investments are taking place and the need to consider the effects of educational technology investments on the environment. To ascertain the environment context of a given country, the World Population Review (2021) documents the country's carbon footprint record, which can also be applied in smart education policy contexts. To date there are no measures of carbon emissions of educational technologies (Freitag et al., 2021). More recently Crawford (2021) highlighted how the extractive practices of the technologies and AI industry will have profound costs in terms of the future of the planet. Of the ten case study policies, the UK's national AI strategy is one of only a few that states in its policy rationale the need to take the lead in addressing challenges posed by AI such as net zero and environmental sustainability (HM Government, 2021).



### Possible tensions and gaps related to policy context

The tensions that are likely to emerge with reference to policy contexts include limited appreciation of specific local and national contexts when compared with the policy contexts of countries that are vastly different culturally, historically, politically and economically.

They also include the existing tension arising from public education systems focused on the common public good interacting with private multinationals, EdTech start-ups and their commercial products as articulated in UNESCO (2015b). These are likely to become more significant during attempts at smart education policy development. The emergence of private virtual education institutions is linked to the marketization of education systems, but growing a commercial and industrial sector in exponential technologies is also a salient commitment in policy.

A third tension that will likely arise in the policy development process is the contradictions related to the globalization and digitization cultures and their modernization agenda as they are perceived to encroach upon local traditions and cultures.

A fourth area of tension is between the need to consider environmental sustainability and rising investments in environmentally destructive smart education technologies without responsible climate-friendly environmentally sustainable considerations.

Thus, the tensions between local and global contexts, public good and private interests, global and local cultural interests, technological solutionism, and environmental protection interests will likely continue to manifest in the policy domain, which suggests that policy will need to find a way to respond appropriately to these contradictions and complexities.

## Policy rationale

To date, various ICTE and smart education policies have articulated different rationales for policy adoption. Without a clear rationale, 'policy becomes techno-centric, promoting the purchase

of equipment [or technological/algorithmic products] or the training of teachers without providing a strong educational purpose or goal for the use of technology' (Kozma, 2008, pp.1084–5).

Many of the case study policies have a dominant economic and labour market rationale alongside an educational rationale. For many countries, global competitiveness, performance in global rankings and human capital development that is responsive to the changing needs of the labour market and enhances the development of twenty-first-century skills are the most critical policy imperatives.

Piattoeva and Gurova (2021) show how the rationale of education modernization in Russia intends to ensure the global competitiveness of Russian education and for Russia to become one of the top ten countries in terms of the quality of its education system and its performance in international assessment rankings. The theme of global competitiveness is also evident in China's Education Modernization 2035 plan. One of its goals is to build a more competitive China. It also acknowledges in its New Generation Artificial Intelligence Development Plan that AI has become the new focus of international competition.

Emerging smart education policies state the rationale as a need for national education systems to create value in its response to the speed, breadth and depth of technological change and the power of exponential technologies in transforming governments, economies and society. See, for example, South Africa's ministerial task team's report on 4IR in the country's post-school sector (South Africa Department of Higher Education and Training [DHET], 2020).

India's AI strategy highlights the rationale for responding to a growing youth population and the need to leverage AI for economic growth and social inclusion.

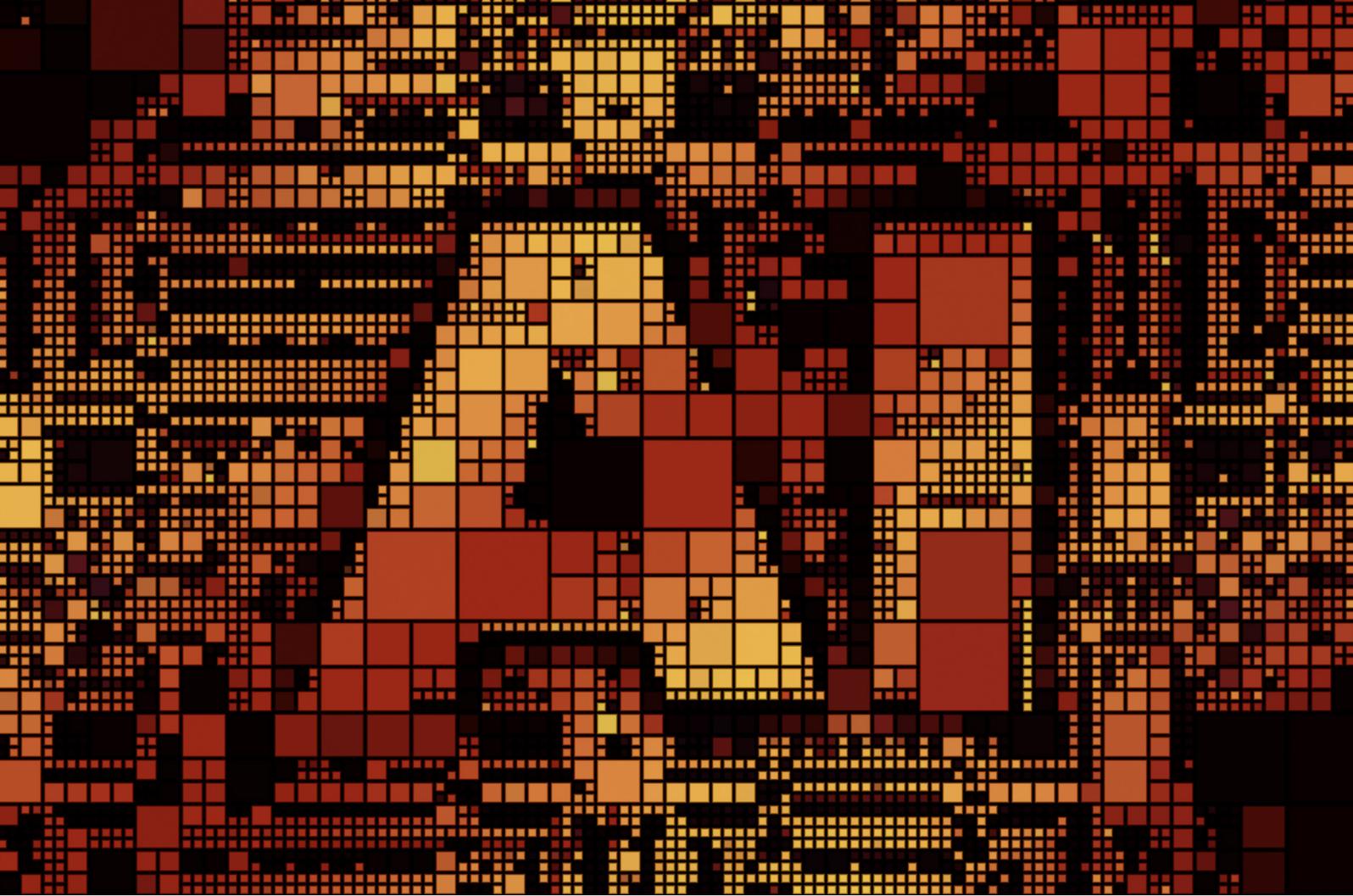
Egypt's AI strategy rationale is manifold and focuses on leveraging AI to build a modern state to achieve Egypt's development goals and improve the quality of life of its citizens; indigenizing the AI industry and strengthening Egypt's leading role in the region and across the world; encouraging dialogue with stakeholders and learning from best practices on developing and using AI for the common good; and applying AI to areas such as education to help overcome staff shortages, improve access and reduce risks and costs. The strategy promotes Egypt as a regional hub for AI education and talent that can serve local, regional and international markets.

The rationale for an AI strategy in Mauritius focuses on the affordances and capabilities of AI to contribute towards economic, social and financial gains; AI's potential to be a vector in the revival of traditional sectors in the economy; and the fact that AI systems can create new opportunities for the development of Mauritius.

Singapore's national AI strategy's rationale is informed by both economic competitive priorities and the shifting geopolitical landscape both globally and in the ASEAN region, which has been underscored by the influence of rapid technological growth and diffusion. The Singaporean Government adopted its AI strategy to enable the country to survive and thrive in a globally competitive environment by building its technological capabilities. The policy rationale is also motivated by a drive for economic transformation, including the redesign of business models and new growth areas for improved productivity gains.

South Korea's national AI strategy rationale centres on the changes that are happening because of AI and the future possible development of AI and innovative growth, whereas the UK's national AI strategy is articulated in terms of:

- the potential of AI to transform the UK's economy, improve people's lives, transform industries and deliver first-class public services;
- AI being critical to the UK's economic and national security;
- the UK's need to prepare for the opportunities that AI brings;



- the leading role that the UK already plays globally in AI;
- the UK's need to take the lead in addressing the challenges posed by AI, such as net zero, health resilience and environmental sustainability; and
- the UK Government's strategy to strengthen its existing international influence as a global science superpower.

Thus, there seems to be a convergence across the case study countries on the rationale for policy and strategy on AI that is underpinned by the need to respond to demands for global economic competitiveness, safeguard state security, grow local AI skills and talents and the local AI industry and, in some cases, promote social inclusion. The rationales also suggest that because of growing algorithmic capabilities and their influence on education, economy and society, the conditions for education policy and governance are being reframed and reshaped.

In the context of a pandemic-prone world, the need to also foreground pedagogies of care, challenging intersecting vulnerabilities and varying forms of inequalities have emerged as crucial points in policy rationales. However, these dimensions are not stated explicitly in the rationales of more recent smart education policies.

## **Problem-responsive policy**

The stated policy rationale for smart education policy will require clarity on the nature of the problems that the policy is seeking to address. For example, education and skills development challenges have been analysed as being highly complex or wicked problems (Rittel and Webber, 1973). Wicked problems are often poorly defined and involve many stakeholders and actors who make decisions from both similar and contradictory viewpoints. The following examples illustrate how the complex problems that macro-level policy seeks to address are framed in existing global frameworks, national AI strategies and national smart education policies.

## Human capital misalignment

Many existing smart education policies suggest that they are responding to a growing misalignment between the skills needs of the labour market and economy, and the skills that the education and skills training system is producing. In the context of an increasingly automated, algorithmic and data-intensive fourth industrial revolution, the need for new skills to design, develop, maintain and use emerging exponential technologies to enable new ways of thinking, learning, working and creating value is an undeniable priority. The reference to data-intensive systems and datafication alludes to the way in which emerging algorithmic technologies are premised on the amplification of the production, use and extraction of big data in increasing volumes, with increasing velocity and variety for commercial, economic, governance and surveillance purposes. In this sense, 4IR technology systems are data-intensive and designed purposefully for datafication, with the latter defined as new ways of measuring, capturing, describing and representing social life in computable numbers.

Many policies seek to address the view that prevailing education and skills development systems, institutions and curricula are not meeting or reflecting the needs of a fast-changing labour market and that economies need to develop smart economic and industrial sectors that demand technology-intensive, algorithmic-intensive skills. In addition, there is a need for existing slow, bureaucratic state systems, many of which operate under systemic capacity constraints, to be more agile and responsive.

Egypt's national AI strategy identifies a brain drain of AI talent who leave the country once they have been trained, and the Mauritian national AI strategy highlights the prevalence of an AI skills crisis, which is defined in human capital terms as a growing labour market demand for more advanced, specialized skills in the workplace. The Mauritian strategy report identifies a capability gap in the recruitment of workers with high-demand skills and talents such as data science skills, cybersecurity skills, and computer science and advanced STEM skills. The skills gap is attributed in part to the fact that many academic and training institutions have not been able to keep pace with innovation and changes to teach the requisite skills.

In South Africa, the ministerial task team report on 4IR for the PSET system adopts a human capital approach to framing the problems that a proposed policy on 4IR needs to address in the PSET sector. The report states, 'From a human capital perspective, the country is not producing what is needed to maximize 4IR opportunities' (DHET, 2020, p. 29). It also identifies related systemic challenges such as youth unemployment and the limited effectiveness of significant investments in youth capacity-development.

South Korea's AI strategy states that the country faces an absolute shortage of AI talent compared to other leading countries, and it is expected that the lack of human talent will be intensified due to increasing demand in the AI industrial field. Similarly, in the UK, the national AI strategy acknowledges the significant and growing gap between the demand for and supply of AI skills despite several new AI skills initiatives since the government adopted the AI Sector Deal in 2018 (HM Government, 2018). The strategy reports that in 2020, there was a 16% increase in online AI and data science job vacancies and 69% of vacancies were hard to fill; that there were significant barriers in recruiting and retaining top AI talent within the UK; and that technical AI skill gaps are a concern for many firms (HM Government, 2021).

## Deep-seated education quality challenges

Some policies are more explicit about the need to address deep-seated education quality challenges. India's national AI strategy expressly highlights the need to address low retention rates, school dropout rates and poor learning outcomes, which it states are linked to multigrade and multilevel classrooms; the lack of interactive pedagogy and ineffective remedial instruction; inadequate attention and proactive responses to students who are likely to drop out; high levels of teacher vacancies; the limitations of teacher professional development systems; and low technology adoption among teachers.



South Africa's ministerial task team report on 4IR in the PSET system refers to the binding constraints in the basic education sector in South Africa, foremost of which is that the quality of education is influenced by the quality of the country's teachers.

Singapore also articulates its AI strategy within the framing of education quality challenges. Specifically, it highlights the differential learning needs, aptitudes, strengths and interests of students and the limitations that teachers face in personalizing students' learning experience. Teachers are also limited in their ability to provide continuous and detailed feedback for every student, not least because their routine daily tasks are time-consuming. The framing of these challenges highlights the need to leverage the affordances of AI technologies in education, particularly those that can assist with personalized learning and foster efficiency gains.

### Learning loss and learning quality

The prevalence of a deepening learning crisis, which the COVID-19 pandemic has exacerbated, has also been highlighted as a rationale for educational technology investment in policy. This problem has been framed as systemic and unequal learning loss with potential long-term repercussions (Azevedo et al., 2020). There are varied perspectives on what learning loss looks like, ranging from a focus on the loss of teaching and learning time to a more comprehensive view that takes into account the complex intersecting vulnerabilities and inequalities in the lives of learners and their communities that manifest as learning loss. For some, learning loss relates also to deficits in teachers' skills and competencies. A responsive smart education policy needs to engage with complex learning challenges and strengthen instructional core capabilities and learning communities in the education system. The causal links to these problems further relate to the prevalence of rigid curriculum frameworks, the systemic lack of appropriate teacher competencies and education management inefficiencies. Here too the consequences of lost learning and its effects on learning quality are related to multiple forms of educational inequalities.

Because many smart education policies and strategies were developed before the COVID-19 pandemic, they do not all take into account the effects of the pandemic on learning quality and existing multiple inequalities. Emerging policies must address the various effects of the pandemic and pay attention to remedial, care and social justice agendas, particularly in the most excluded, marginalized and under-resourced communities.

Following a survey of 142 country responses to the COVID-19 pandemic, the World Bank, UNESCO and UNICEF partnered to design a global education recovery agenda in 2021 (World

Bank, UNESCO and UNICEF, 2021). It highlighted three priorities for all countries to be addressed by 2022:

1. All children and youth should be back in school and receive the tailored services needed to meet their learning, health, psychosocial well-being, and other needs.
2. All children should receive support to catch up on lost learning.
3. All teachers should be prepared and supported to address learning losses among their students and to incorporate digital technology into their teaching. (World Bank, UNESCO and UNICEF Bank, 2021).

The three organizations established systems and processes to support individual country governments with appropriate responses to their respective learning loss crises. How these demands dovetail with parallel processes towards adopting technologies in education will remain an important consideration for emerging smart education policies.

## Systemic inequalities, vulnerabilities and exclusions

Smart education policies in most countries are responsive to various forms of systemic inequalities as they manifest in education systems. These include the structural ways in which unequal access to education; gender inequality; ability-disability inequalities; spatial inequalities within and between rural and urban areas; racial, cultural, religious and ethnic disparities; citizenship status; income inequality; and digital inequality intersect in complex ways. The South African report on 4IR for the PSET system refers explicitly to the challenges of growing poverty and inequality, to which policy needs to respond.

The USA's NETP highlights the need to address persistent problems, including digital inequality and the digital divide. In addition, few schools and districts have adopted approaches to using technology to support informal learning, many pre-service teachers feel unprepared to use technologies to support student learning, assessment approaches still do not use technologies to their full potential, and network security is a growing concern as internet-accessible school data, management and learning systems become more common and the sophistication of attacks, including the use of ransomware, on school networks grows.

## Newly emerging inequalities and the COVID-19 pandemic

The rapid growth and diffusion of exponential technologies is also leading to new problems and crises, including algorithmic biases, the emergence of new forms of inequalities such as redlining, data privacy and security, and surveillance (Williamson, 2020). These problems can be framed in broad terms as part of a generalized policy problem statement and they can be restated under specified themes related to smart education policy, which this framework also proposes.

While the COVID-19 pandemic accelerated the adoption of digital tools and approaches in education, it also highlighted the worsening inequalities – including gender inequality through rising teenage pregnancies, more girls than boys dropping out of school, gender-based violence, health care access and unequal access to psychosocial support systems (United Nations, 2020) – which will also demand smart education policy attention. It also revealed the extent of digital inequalities. In addition to existing digital inequalities, often referred to as the digital divide, Vincent-Lancrin et al. (2022) observed that a gap between the technologies available to education system stakeholders and the frontiers of advanced technologies was also evident during the pandemic.

## The lack of AI research and AI application expertise

All the national AI strategies emphasize that the lack of AI research and application expertise within their respective countries is a critical systemic problem that must be addressed through national policy and strategy. The Indian, Mauritian, Singaporean, South Korean and UK national

AI strategies state explicitly that their countries lack broad-based expertise in research and the application of AI and prioritize this particular problem.

### Data governance, cybersecurity and data privacy risks

National AI strategies reflect the need to respond appropriately and effectively to inherent risks arising from poor data governance, threats to cybersecurity and data privacy, all of which invariably accompany growing investment in AI and related technologies and their integration in social systems like education. The Mauritian, Indian, South Korean and UK national AI strategies specifically highlight the need for policy and strategic responses to cybersecurity breaches and threats to data privacy, whether they come from hackers or from what AIs have learned from analysing data and making decisions without human intervention. The latter increases the power of AI especially when larger volumes of data are involved, which intensifies the risk of infringements on the right to privacy and data protection. This problem is exacerbated by poor data governance.

### Ethical and moral challenges

National AI strategies further highlight the ethical and moral challenges that increasing investment in AI and related technologies pose to society, and this requires concerted policy attention. The Mauritian AI strategy highlights ethical and moral challenges from the perspective of AI systems not having the capability to make fair and moral decisions because it is challenging to integrate ethical and moral issues in the training of AI systems. The risk of amplifying and reproducing structural discrimination is intensified particularly in the absence of an explicit code of ethics and appropriate AI governance. Similar observations about addressing existing and impending ethical and moral challenges are found in the UK, South Korean, Singaporean and Indian AI national strategies.

## Policy vision, values and principles

While many educational technology and emerging smart education policies are anchored in an aspirational, inspirational vision statement anticipated to be achieved over a decade or two, Trucano (2016) reviewed eighty country policies and found that many did not have a clear vision statement. Themes that are emerging in smart education policy vision statements include references to a transformed, agile, innovative education system that is responsive to the needs of a fourth industrial revolution and is equitable, inclusive and sustainable, a system in which everyone is connected, capable, people-centred and productive and leads a healthy life. For example, Singapore's fourth ICT masterplan vision is to nurture 'Future-ready and Responsible Digital Learners' (Natarajan et al., 2018).



### Possible tensions and gaps related to defining smart education policy problems

The tensions that are likely to emerge in the formulating of relevant policy problem statements include tensions between the need to prioritize growing social inclusion and equity demands and climate emergency demands relative to prioritizing investment in high-end technologies across national education and training systems.

The complexity tensions that will invariably accompany growing investment in AI and related technologies such as the greater risk of data privacy infringements, surveillance, ethical infringements, and creating more humane, ethically responsible technologies are further contestations that are likely to arise, as are tensions arising from servicing the interests of the public good relative to the needs of a growing EdTech industry.

## Policy and strategy statements as faith-based aspirational statements

Much of the policies, strategies and plans among the ten case study countries articulate vision statements as statements of intent and aspiration. Many articulate their vision statements, desired goals and outcomes in broad aspirational terms. Often the aspirations appear to be faith-based and are not always informed by or grounded in evidence. Table 4 compares the vision statements of a sample of transversal digital and AI policies from six of the ten case study countries that had adopted AI strategies or documented reports that include plans for AI or 4IR strategy adoption. It shows that the visions of smart education policy embedded in transversal national policies in Mauritius, Singapore and the UK express aspirations for an innovation-driven culture (Mauritius), becoming a global hub for developing AI solutions (Singapore), and establishing the most trusted and pro-innovation, trustworthy and ethical system for AI in the world (UK).

**Table 4. Comparing vision statements of a sample of case study transversal policies**

Country national policy or strategy	Espoused vision
<b>Egypt National AI Strategy</b>	The vision positions Egypt as a leading global player by mobilizing AI technologies to serve both developmental and global economic competitive goals. It aspires to create an AI industry, and develop relevant skills for sustainability and competitiveness.
<b>Digital Mauritius 2030 Strategic Plan</b>	The vision is for a highly interconnected society with access to the knowledge required for an innovation-driven culture.
<b>The National AI Strategy (Singapore)</b>	The vision is for Singapore to be a leader in developing scalable, impactful AI solutions in key sectors of high value and relevance to Singapore's citizens and businesses; for Singapore to be a global hub for developing, test-bedding, deploying and scaling AI solutions; for AI to raise the Singaporean Government's capability to deliver anticipatory and personalized services, and be a strong driver of growth in key sectors of Singapore's economy; for Singaporeans to understand AI technologies and their benefits; and for Singapore's workforce to be equipped with the necessary competencies to participate in the AI economy.
<b>UK National AI Strategy (2021) (including Scotland's Artificial Intelligence Strategy)</b>	The ten-year vision is for the UK to maintain and build on its position as a global AI superpower. Its vision in this respect is to lead the world as a research and innovation powerhouse, a hive of global talent, a progressive regulatory and business environment and the 'best place to live and work with AI with clear rules, applied ethical principles and a pro-innovation regulatory environment'.
<b>South Africa's Ministerial Task Team Report on 4IR and PSET</b>	The vision is of a PSET system integrated with 4IR technology systems that are aligned with the national country vision as outlined in the South Africa Government's National Development Plan (NDP) 2030, and suggests that 4IR technologies and tools be harnessed to create a better, more inclusive, wealthier South Africa whose benefits are enjoyed by all its citizens.
<b>South Korea</b>	The vision is for South Korea to lead the world in the global AI sector

Vision statements are also underpinned by stated values and principles. These principles reflect aspirational ideals that guide decision-makers and actors along a shared understanding and pathway. The most salient guiding principles that inform thinking, decision-making and ICTE smart education practice tend to emphasize inclusion and equity imperatives, including gender equity; principles focused on transparency and openness; humanistic, empathetic, auditable, responsible and ethical technology design; and user safety. For example, India's national AI strategy explicitly states certain values related to 'responsible AI' and highlights seven principles that align with a responsible AI approach. They build on the principles of:

- Safety and reliability
- Equality

- Inclusivity and non-discrimination
- Privacy and security
- Transparency
- Accountability
- Protection and reinforcement of positive human values

The UK's national AI strategy makes explicit reference to the need for ethical principles. Similarly, policies in Egypt, South Korea, Singapore and Mauritius reflect commitments to values of safety, equality, privacy and security. These principles and values are to be understood and applied as broadly stated commitments to the idea of responsible AI.

## Smart education policy goals and intended outcomes

Many ICTE policies outline clear objectives and goals, which are linked to policy rationales and policy problem statements. These goals and objectives tend to include promoting equitable access to digital and smart technologies for learners, teachers and faculty; improving the quality of learning and teaching; improving institutional and national system educational efficiencies; enabling the design of safe, culturally appropriate, inclusive technologies; providing an enabling environment for active citizenry who are productive, innovative and lead sustainable livelihoods; and enabling research and innovation in higher education. The goals and objectives for smart education policies are more oriented to growing AI and 4IR skills, talents and capabilities, and building research capability to lead AI- and 4IR-related innovation.

## From learning for everyone, everywhere, all the time to AI skills for everyone

All ICTE policies include ubiquitous quality learning enabled by technologies as a goal. For example, the USA's 2017 National Education Technology Plan states as its goal: 'All learners will have engaging and empowering learning experiences in both formal and informal settings that prepare them to be active, creative, knowledgeable, and ethical participants in our globally connected society' (Office of Educational Technology, 2017a). South Africa's e-Education White Paper (South Africa Department of Education, 2004) sets similar goals, as do the initial ICTE masterplans of South Korea and Singapore. With the emergence of smart education policies, though, the goals shifted more towards building AI skills for everyone. For example, South Korea's national strategy calls for the provision of AI educational opportunities at various levels and locations outside of schools, finding and nurturing AI-gifted students, ensuring educational opportunities for vulnerable groups and rural residents, and training instructors.

## Digital, 4IR and AI infrastructure to enable predictive learning for everyone, everywhere, all the time

All ten countries that were studied have policies that state a goal to expand access to education, learning opportunities enabled by physical access to digital technologies (devices, educational software, connectivity) and digital learning resources enabled by artificially intelligent, predictive capabilities. However, for the latter to occur, a basic digital infrastructure needs to be in place. Thus, the goal in AI in education policies can only be achieved if digital learning policy targets for basic digital learning infrastructure have been met. For example, the USA NETP states as a goal that all students and educators will have access to a robust and comprehensive infrastructure when and where they need it for learning. The South African e-Education White Paper set ICT infrastructure access goals for 2013, which were not met, yet the goal remains relevant alongside the emergence of exponential 4IR technologies. The MTT on 4IR in the PSET system in South Africa highlights digital access to devices and connectivity for students and

faculty as a policy goal, one that remains not only relevant but also critical. Access to 4IR and AI infrastructure is less explicit in national AI strategies and some, like Egypt, focus on access issues in their national digital strategies.

## Equity, inclusion, human rights and fundamental freedoms

All policies on ICTE and smart education are underpinned by commitments to the goals of equity, inclusion and human rights. Some highlight inclusion and equity issues more explicitly than others and are less explicit about commitments to social justice beyond rights-based approaches. These are linked to commitments to people-oriented, people-centred solutions and liveability, and mutual understanding across cultures, as expressed in the ASEAN Smart Cities Framework. India's national AI strategy sets as one of its goals leveraging AI for social development and inclusive growth. Similarly, South Africa's MTT on 4IR in the PSET system makes explicit statements about policy commitments to equity and inclusion. Egypt's national AI strategy proposes to capitalize on AI as an opportunity for inclusion of the marginalized and the development of initiatives that promote human advancement and self-development.

## Becoming a world leader in AI or the world's AI hub

Where national AI strategies were adopted, a few stated an ambition to be a world leader in AI, whether it was in research, innovation or the development and export of AI products. For example, the UK, South Korea and Singapore state policy goals to be global leaders in a competitive AI world. In the UK, the strategy goals are for the UK to increase the number and type of made-in-the-UK commercialized discoveries; to benefit from the AI-related economic and productivity growth; and to establish the most trusted pro-innovation system of AI governance in the world. India sets a goal to become the world's AI innovation hub.

## Safe, ethical, trustworthy, humane design and responsible use of technologies

Smart education policy goals are also explicit about the need to ensure that the design and use of exponential technologies in education are safe for all children, youth and adults, that they observe the ethical principle of doing no harm and that they promote humanistic-centred technologies.

Singapore states a strategy goal to promote a human-centric AI approach where people's well-being is prioritized, and to facilitate multistakeholder dialogues that can inform policy development on the deployment of responsible AI for the benefit of society. Egypt's national AI strategy shares this goal, but it further commits to capitalizing on AI as an opportunity to include marginalized groups, not only in safety net programmes but also in initiatives that promote human advancement and self-development (NCAI, 2021).





### Possible tensions and gaps related to policy goals and outcomes

The tensions that are likely to emerge in relation to stated policy goals will revolve around which goals are prioritized and explicitly stated and which are not stated. For instance, few smart education or ICTE policies articulate gender equity or the promotion of open educational resources and practices as explicit objectives. Moreover, some policy goals are at odds with one another. A commitment to a competitive economy will be at odds with a commitment to an equitable, sustainable environment, for example.

In many policies, the goals and outcomes are not defined in achievable, measurable or evidence-based terms and are often expressed in aspirational, faith-based terms, pointing to the likelihood that they may not be achieved or, if they are, their achievement would be limited. This points to the need to reconcile aspirational goals with complex realities.

## Policy themes

### Policy theme 1: Infrastructure

Historically, ICTE policies have focused on goals that involve universal, ubiquitous access to digital infrastructure to support learning, teaching and education management, administration and governance. Successive waves of ICTE policies across the ten case study countries focused on progressive levels of digital infrastructure access for learners, teachers, education institution administrators and managers at different levels of the national education and training systems. They ranged from initial access to computer laboratories in the 1990s to increasingly mobile, personalized connected devices and related support infrastructure. The latter includes:

- sustainable **energy/power** solutions for education institutions;
- low-cost affordable, safe, ubiquitous and **meaningful connectivity** (Alliance for Affordable Internet, 2020; Katz and Gonzalez, 2016) and network management at education institutions (schools, universities, colleges, community centres);
- **home internet access** for staff and students;
- sustainable access to and use of **appropriate connected devices** where specifications for learning, teaching, administration, equity and inclusion are considered;
- access to **zero-rated platform ecosystems**;
- **smart classrooms and campuses** that use technologies ranging from SMART boards to virtual reality and hologram technologies to provide interactive displays, personalized immersive learning and teaching experiences (Huang et al., 2019);
- **technical support**, upgrades and maintenance;
- **carbon emission management** of technology adoption (Freitag et al., 2021) for learning and teaching;
- managing **responsible disposal of e-waste** from educational technology investments; and
- promoting **responsible, safe use** of digital infrastructure to support learning.

Many digital infrastructure issues were expressed in policies as targets to be reached, and to date, across the ten countries, universal, equitable digital infrastructure access remains uneven. For example, Egypt's national AI strategy is linked to its Digital Egypt strategy, which is intended to address the continuing limited digital access in education institutions. It states that Egypt's universities and research institutions have neither a wide enough internet bandwidth to support big data, especially when required to be processed remotely, nor enough computing power to run AI applications. For this reason, the government proposes to build on the Digital Egypt strategy by expanding AI infrastructure.

South Africa's MTT report on the PSET system recognizes that basic digital infrastructure access challenges prevail despite targets in government policy for improved digital access. For this reason, the report recommends that an integrated ICT plan be developed for the PSET system that includes the provision of affordable ICT devices and connectivity to all PSET students to ensure equitable access to learning opportunities through the affordances of the 4IR.

The USA's NETP makes a case for the development of equitable, accessible robust technology infrastructure across education institutions. It proposes:

- ubiquitous connectivity that provides consistent access to high-speed internet in and out of school;
- powerful mobile learning devices that connect learners and educators to the vast resources of the internet and facilitate communication and collaboration;
- high-quality digital learning content and tools that can be used to design and deliver engaging and relevant learning experiences; and
- responsible use policies (RUPs) to guide and safeguard students by adopting practices that use the infrastructure to support learning.

The NETP recommends that students and educators have broadband access to the internet and adequate wireless connectivity, with a special focus on equity of access outside of school; that every student and educator has at least one internet access device and appropriate software and resources for research, communication, multimedia content creation and collaboration for use in and out of school; support for the development of openly licensed educational materials; and the creation of a comprehensive map and database of connectivity.

Egypt highlights the need for digital infrastructure to be in place, as expressed in its previously adopted Digital Egypt strategy, so that data-driven AI technologies can be integrated in education and training institutions. South Korea's national AI strategy proposes the establishment of a giga-speed wireless network in elementary and middle schools across the country.

### Educational technology access issues resurfaced during COVID-19 pandemic

While the COVID-19 pandemic was seen by many as a catalyst for the adoption of digital learning by governments across the world, it also exposed the prevalence of digital inequality, including in countries like the USA. Vincent-Lancrin et al. (2022) show how the COVID-19 pandemic highlighted the nature and extent of digital inequalities within and between countries and that a range of strategies was adopted to enable learning continuity under lockdown conditions. The latter included the use of analogue technologies such print worksheets, radio and television alongside the use of low-end mobile chat platforms and high-end online learning platforms as part of government response strategies.

Rodríguez and Cobo (2021) showed how mobile phones were among the most used tools in resource-challenged contexts to facilitate the exchange of learning materials and communication between teachers, parents and students in urban and rural areas while students were learning remotely at home. The home as a pedagogic space for learners emerged as a central feature in the plans and programmes for enabling learning continuity. The pandemic also exposed various forms of inequality in the context of unequal access to spaces to study in the home and how conditions in the home contributed to additional intersecting inequalities, such as increased levels of gender-based violence, mental health challenges and food insecurity. Many, albeit limited, attempts were made to address the inequities – for example, zero-rating ministry of education-endorsed educational websites, as in South Africa, so that students and teachers could access and use learning resources at no cost from a range of mobile and digital devices (Soudien et al., 2022).

## Technology frameworks for smart learning and teaching

In parallel with the need to strive for ubiquitous access to digital infrastructure, smart education policies and existing transversal smart economy and 4IR frameworks anticipate a rapid diffusion of intersecting exponential technologies across national education systems. These include AI, blockchain, IoT, 3D printing, wearables, augmented reality (AR), virtual reality (VR), big data, learning analytics, adaptive instructional systems and personalized learning. To date, for instance, AI systems are integrated into teaching and learning, learning management systems, proctoring, grading/assessment, student information systems, office productivity, library services, admissions, disability support and mobile apps in many countries including the national case study countries. Smart education policy responses to the onslaught of a suite of high-end exponential technologies are expressed as system-wide integration for learning, teaching assessment, education management and governance rather than on issues related to access to AI and related technologies.

The need for technological frameworks and standards has arisen in both policy deliberations and the literature. Demir (2021) and Huang et al. (2019) provide extensive examples of a growing range of smart education technologies, their affordances, and their functionalities to enable smart learning, teaching, assessment, administration, management and governance within learning institutions. They provide considerations for technology frameworks that take into account different dimensions of the smart learning and teaching ecosystem, ranging from the perspective of the student as user to the perspective of the teacher; classroom, campus-wide and institutional perspectives; and more broadly, networks of institutions within district, regional and national systems. The frameworks also include the adoption of technological architectures that can align with institutional contexts.

## Technology standards

Demir (2021) states that standards are also essential for the development of smart education because it heavily relies on ICT. The International Standards Organization (ISO) has a group (ISO/IEC JTC 1/SC 36) to support the development of standards for ‘information technology for learning, education, and training’. International associations such as the International Association of Smart Learning Environments are being formed to support the development of smart learning environments (see <http://iasle.net/>). Various telecommunications and information technology companies have also started to invest in the education business. Technology giants such as IBM and Samsung, for example, are developing information technology architectures and solutions for smart education systems (Hoel and Mason, 2018).

In tandem with the growing involvement of large technology corporations in setting educational technology standards, there have been calls for the adoption of open, non-proprietary standards, including in the development and evolution of the internet (Internet Society, 2015).

Open standards refer to standardized ways of formatting, writing, sharing, retrieving and verifying data. The advent of blockchain technology has spurred considerable innovation in open standards as companies, governments and individuals realize the need for a shared method of verifying what is true. Shared methods reduce vendor-dependency, helping organizations and individuals avoid the kind of lock-in that comes from platform-dependent ways of managing data. Open standards have been instrumental in the development of the Internet over the past several decades, as demonstrated by the work of the Internet Society (2020). A host of international standards committees and groups are converging to collaborate on setting appropriate educational technology standards. The adoption of these emerging standards is a further consideration for smart education policy development.



### Possible tensions and gaps related to smart education infrastructure

Investment in technology infrastructure has sparked many debates about the pedagogical, equity, ethical, safety, culturally responsive and environmental value of the investments. Policies will need to be responsive to these tensions, especially in view of the resource-intensive investment that they require at institutional and system levels.

Another tension relates to the procurement-centric nature of technology investments and the engagement of institutions and education systems with the growing influence of commercialized technology products that are sold and promoted by multinational companies and EdTech start-ups. More recently, there has been discussion about how important it is for policies to guide and direct the democratic design of exponential technologies. In this context, standards on the procurement of educational technologies also need to be set. This too is an issue for policy consideration.

## Policy theme 2: Curriculum and pedagogy

Existing and emerging smart education policies include responses to repurposing and reconfiguring curricula and pedagogies to incorporate lifelong learning and the development of appropriate skills and competencies that respond to the needs of an economy and society in which 4IR technologies are spreading rapidly. The centrality of pedagogical and curriculum considerations has also arisen amid concerns that they have been eclipsed by the dominance of technological and economic factors in the design of smart education and ICTE policy and practices.

The curriculum and pedagogy considerations in smart education policies are also informed by underlying theories and philosophies on learning and the role of digital and exponential technologies in rendering learning and teaching more effective, efficient and labour-market-relevant. Various pedagogical approaches have framed the integration of digital technologies in learning and teaching. A techno-centric, techno-positive sentiment in global socio-technical imaginary on digital and smart learning, heightened amid the COVID-19 pandemic, emphasized how the affordances of quantifying data-driven technologies catalyse improved learning, teaching and learning outcomes. Such approaches, as shown by Watters (2021), are associated with behaviourist learning methodologies that are accompanied by didactic, knowledge-transfer, instruction-led approaches focused on cognition and memorization.

Connectivism approaches take for granted that technologies play a major role in learning and that constant connection opens new learning vistas such as group work and collective problem-solving. Constructivist and asset-based approaches centre the agency and knowledge of learners within their respective contexts and communities whose learning is situated in context, and where knowledge is constructed through interactions within peers and experts, communities, and local physical, cultural and systemic environments in supportive, caring, ethical and nurturing ways.

These various pedagogical approaches have also surfaced in ICTE policies and practices and, more recently, in smart education and have triggered debates about appropriate digital pedagogies.

## Shifts to competency-based curricula

Many governments have accompanied the adoption of digital and smart technologies in education with shifts from rigid, structured systems towards more flexible competency-based curriculum frameworks. In competency-based curriculum frameworks, the focus is on developing knowledge, skills and values in context through assessments and with the requisite support.

## Pedagogical shifts and COVID-19

Shifts in approaches to pedagogy and curriculum emerged during the COVID-19 pandemic. Government responses to the pandemic, especially in the initial lockdown period, highlighted the importance of educating the whole child. The centrality of safety, food security, and mental and emotional support re-emerged as crucial aspects of holistic, empowering approaches to learning (Vincent-Lancrin et al., 2022).

Renewed calls to humanize learning and teaching were made, drawing on the work of Noddings (1992) and Palmer (1998) which promoted the notion of pedagogies that are grounded in compassion (International Commission on the Futures of Education, 2021).

This section of the framework considers the way pedagogy and curriculum matters are framed in existing smart education policy texts across the ten case study countries and the emerging pedagogical issues and debates that were raised within the COVID-19 pandemic context.

## Datafication of pedagogy, pedagogical practices and assessment

In policy texts, pedagogical approaches are increasingly defined as smart learning or smart pedagogies. Zhu et al. (2016) suggest that a smart pedagogy framework includes class-based differentiated instruction, group-based collaborative learning, individual-based personalized learning and mass-based generative learning. This is echoed by Dillenbourg (2021, cited in OECD, 2021) who observed that smart learning moves beyond personalized learning focused on the individual and considers the classroom as a digital system, and thus the classroom moves beyond the physical into the digital world.

In 2011, the Korean SMART policy defined smart learning as an intelligent, tailored instruction-learning supporting system, in which the demands of the 21st century information technology society are met with changes in the overall education system such as pedagogy, curriculum, assessment, and teacher. It is a combination of human-centered social learning and adaptive learning, based on the best network communication environment. (Republic of Korea, 2011)

Since 2011, smart learning has evolved into increasingly artificially intelligent, algorithmic and datafied pedagogies.

A systematic literature review of 1,830 research articles on AI in education conducted by Feng and Law (2021) revealed the centrality of two trends: the use of intelligent tutoring systems (2010–19) and the use of massive open online courses (MOOCs) (since 2014), both of which are data-driven assessment and learning systems. It also found that the focal educational concerns reflected in AIED research are:

- online learning,
- game-based learning,
- collaborative learning,
- assessment,
- affect,
- engagement, and
- learning design.

This resonates with the findings of Huang et al. (2019), Luan et al. (2020) and Pedró et al. (2019): the next level of key pedagogical issues relates to AI systems applied to education. These key investments assume the following forms:

- **Intelligent tutoring systems (ITS)**, which track and model student development, personalizing (Huang et al., 2019) learning by offering content, pedagogical strategies and motivational triggers adapted to the needs of each learner and even step-by-step assistance to help them work on problem areas.
- **Facial recognition**, for the monitoring of learning based on the recognition of facial and voice expressions.
- **Educational chatbots**, which use natural language processing to communicate with learners, give them guidance and feedback, and point them toward helpful resources.
- **Affective computing**, which uses AI to measure the affective states of learners and can act to keep or alter such states, as needed.
- **Autonomous computer systems as pedagogical agents** to observe the environment through sensors and use their observations to plan and act in that environment so that students achieve their learning goals. Pedagogical agents are often represented by an avatar and can interact with students by assuming different roles and using different strategies.
- **Big data in the form of learning analytics and data mining**, which have grown significantly in recent years because of the massive use of online and hybrid learning environments, are core to most of these systems. 'Learning analytics refers to the measurement, collection, analysis and reporting of data about the progress of learners and the contexts in which learning takes place' (Sclater et al., 2016, p. 4).
- **Maker spaces**, which involve the conscious creation of learning spaces at school, TVET colleges and universities where groups collaborate in the design and making of products including technology products.
- **Predictive tools to inform pre-emptive action for students predicted to drop out of school**. India's national AI strategy specifies the need to invest in predictive tools that provide analyses of test results and attendance records using AI. These can be used to predict probable student activities and inform pre-emptive action. Smart education policies across the world refer to the value of investment in these data-intensive pedagogies which provide many options for learning;

problem identification; pattern recognition; finding early indications of success, failure or potential school dropout; personalized learning and self-reflection; early interventions; supervision; and improved teaching.

Examples of these pedagogical applications can be found in China's Notice on the Recommendation and Selection of the Smart Education Pilot Zone Construction Project, which includes the introduction of mechanisms for and approaches to promoting both teachers' and students' digital literacy, awareness, computational thinking, digital learning and information social responsibility through relevant curriculum and practice. They include:

- hybrid education, learning and assessment;
- assessment of the students' comprehensive quality evaluation supported by AI and big data;
- personalized and on-demand services for teachers and students based on data interoperability provided by government and enterprise; and
- collaborative innovation to promote the supply of open educational resources across regions for equal and inclusive education, empowered by AI and big data.

The government of Minhang District in China formulated and implemented its Plan of Creating a National Smart Education Pilot Zone in Minhang District, which include measures that focus on the goal of delivering teaching that adheres to moral, intellectual, physical, aesthetics and labour requirements as well as personalized and differentiated teaching and learning.

One of Singapore's five national AI projects focuses on personalized education and adaptive learning and assessment in specified subjects to explore ways in which teachers can better customize and improve the learning experience for every student. It is focused on the adoption of an AI-enabled adaptive learning system that is embedded within its learning platform, the Student Learning System. It is intended that the adaptive learning system will use machine learning to enable it to assess individual student responses to learning materials and activities and guide the student on personalized responses, thereby enabling personalized learning pathways for each learner, customized to meet their individual learning needs, and a more efficient assessment of their work with an AI-enabled automated marking system. The marking system can assess open-ended student responses and provide timely feedback, thereby embedding assessment in the learning process. Students would also benefit from holistic development through an AI learning companion that could motivate the student, keep them engaged during challenging tasks, help them reflect on their learning experience, and recommend further learning activities.

## Datafication and the COVID-19 recovery agenda

In 2021, following the findings of a global survey on country responses to the COVID-19 pandemic, the World Bank, UNESCO and UNICEF established a Learning Data Compact. This initiative is a commitment to ensure that all countries, especially low-income countries, have at least one quality measure of learning in place by 2025, supporting coordinated efforts to strengthen national assessment systems. It sprang from the urgent need for timely and quality data on learning and the drivers of student achievement, particularly because of the finding that many countries were not measuring the nature and extent of learning loss caused by the pandemic.

The Learning Data Compact offers a menu of evidence-based methodologies, tools and solutions that were developed by and with developing countries so that they can be applied flexibly to improve timely, quality relevant information that can be drawn from national large-scale assessments. The initiative plans to help countries to:

- plan, design and implement large-scale learning assessments, and then to analyse and use the results;

- produce repeated measures of student learning that are comparable over time and across countries;
- better understand the relationships between large-scale student assessments and classroom assessments;
- support the improved collection and use of census-type administrative school data;
- support the improved coordination, quality, oversight and transparency of global efforts to measure student learning.

The Compact has a 2x2x2 framework in which countries are helped to measure learning in at least two subjects (e.g. mathematics and reading), in at least two grades (e.g. early primary, end of primary, end of lower-secondary), and with at least two planned rounds over five years.

The plan is to ensure that these national learning measurement initiatives are coordinated and supported by international and regional assessment programmes such as PASEC, SEAMEO, SAQMEC and LLECE.

### Lifelong and life-wide learning

Some national ICTE and smart education policies propose that education systems need to be designed to be lifelong – that is, learning can take place at all stages of a student’s life – and life-wide – that is, learning happens not just in an educational setting, but in multiple settings, such as through community or non-traditional providers of education, at home, at work, and in other settings enabled by digital technologies. Learners are encouraged to build e-portfolios over time to document their recognized academic credits and credentials that may be recognized by industry. The USA NETP champions lifelong and life-wide learning as part of proposed improvements in the quality of learning, based on the idea that technologies can enable learning everywhere, all the time. The policy’s commitment to equity and inclusion suggests learning will also be made accessible to all (Office of Educational Technology, 2017a). The Mauritian national AI strategy also proposes investment in lifelong learning with collaboration between education institutions.

### Smart education subjects, algorithmic/computational thinking and hackathons

Most policy responses also embrace curricula changes that are focused on developing skills for a 4IR economy. UNESCO (2022b) has developed a map of government-endorsed AI curricula across the world.

Such curricula changes include a combination of the following:

1. The introduction of new subjects, courses and degree programmes in robotics, coding, data science and AI along with national policies on AI and smart education.
2. The introduction of a personalized and on-demand service for teachers and students based on data interoperability provided by government and enterprise .
3. Non-formal AI courses, data science bootcamps, summer schools and hackathons are organized by higher education institutions to attract the interest of youth and young adults.
4. The introduction of computational or algorithmic thinking in the national curriculum, focused on increasing computational thinking skills based on problem-solving through computational and digital solutions. Computational thinking focuses on how computational concepts, methods and tools can develop thinking skills to transform the way wide-ranging problems can be solved (Wings, 2006).
5. The integration of AI, robotics, virtual reality and augmented reality, and 3D printing in the learning and teaching process.

The UK was one of the first countries in the world to implement computational thinking in its K–12 curriculum (Bocconi et al., 2018). In 2014, the curriculum was organized into four key stages over the span of formal K–12 education. Students are expected to develop their computational thinking skills progressively at each stage and to achieve certain learning outcomes:

- Key stage 1 (5–7 years old): Students create and debug simple programmes
- Key stage 2 (7–11 years old): Students can design, write and debug programmes to accomplish specific goals
- Key stage 3 (11–14 years old): Students can design, use and evaluate computational abstractions that model the behaviour of problems
- Key stage 4 (age 14–16): Students can develop and apply their analytical, problem-solving, design and computational thinking skills (Department for Education, 2019)

Reforms like these pave the way for how other subjects, such as language, mathematics and science, are taught.

Egypt's national AI strategy calls for sample modules that could be incorporated into school curricula, based on its AI4K12 initiative and AI + Ethics course for middle school. In South Africa, coding and robotics are being introduced as new curricula subjects in schools. The country also calls for:

- exposing students to the basics of AI during their school education and teaching AI in a fun, interactive way;
- growing the computing and AI talents of students in TVET institutions and training TVET educators to teach AI-related subjects;
- establishing new, dedicated 'faculties of AI' at its universities; repositioning existing computing and engineering faculties as AI faculties that integrate AI in their course offerings; and developing specialized postgraduate programmes in partnership with AI specialist institutions;
- upskilling professionals working in IT-related jobs with specialized skills in AI system development and developing non-technical professionals as domain experts on AI development teams; and
- developing AI business schools to establish special programmes to equip executive-level professionals and workers in start-ups, government and the private sector with the requisite AI skills and capabilities.

China's national AI strategy highlights the introduction of AI in primary and secondary schools, offering AI-related courses, and gradually promoting programming education opportunities to encourage society to participate in, for example, educational software programming and game development.

India's AI strategy includes the adoption of its New Education Policy (NEP) 2020 and its prioritizing of computer programming and coding as a subject from Class 6 onwards (Ministry of Human Resource Development [MHRD], 2020). The strategy highlights the development of AI courseware and modules that are integrated into the curriculum in schools; some have already been developed through various partnerships. For instance, the NITI Aayog Atal Innovation Mission developed an AI module for school students in partnership with the Ministry of Electronics and Information Technology (MEITY) and National Association of Software and Service Companies (NASSCOM), and MEITY and Intel India have designed a national programme for government schools called Responsible AI for Youth.

South Korea's national AI strategy proposes the full-scale convergence of AI in its education system. This involves:

- easing the regulations to promote the creation and operation of interdisciplinary majors between AI and other majors;
- reinforcing basic education for AI to enable the development of students who can combine their AI capabilities and expertise in other fields such as the humanities, medical science and the arts;
- making AI education compulsory for all students and promoting AI-teaching among teaching staff and faculty to eventually extend its reach to universities nationwide; and
- conducting a systemic revision of the school curriculum to make it appropriate to the needs of an AI-centred school.

The dominant policy considerations include the trends towards increased datafication of pedagogy, pedagogical practices and assessments, and the way new algorithm-based subjects are introduced into the curriculum. These considerations have drawn attention to current gaps and tensions, which emerging smart education policy will need to consider.



### Possible tensions and gaps related to smart education curricula and pedagogy

Within the pedagogical sphere, the philosophical underpinnings that inform policy on how smart and digital pedagogies are understood and framed have raised debates about the practice of using digital technologies for cognition-centred learning, knowledge transfer of scripted curricula and instruction-centred learning models that focus on memorization and rote learning. Watters (2021) explains how behaviourist learning theories have re-emerged with the rise of educational technologies which focus often uncritically on instruction-centred approaches to instructional design, learning and learning outcomes (Murtonen et al., 2017). Opposing views suggest that social, cognitive cultural and affective influences also play a crucial role in the learning process when they are used alongside strategies that enable the agency of the learner. Fataar and Norodien Fataar (2021) cite an e-learning ecologies approach that integrates reflexive pedagogies and design-based learning. The COVID-19 pandemic also renewed interest in the notion of pedagogies of care and how digital pedagogies need to be designed and applied to enable the integration of care and support in learning and teaching strategies.

Digital pedagogies introduce ethical dilemmas in terms of the integration of exponential technologies in data-driven curricula and pedagogical practices. Many of these practices are new, and many people in the education community are unaware of their potential ethical challenges or may not be familiar with how to respond to them. This introduces the potential for sources of tension, and highlights the need for policy guidance on designing and managing data-driven pedagogies and assessment systems.

## Policy theme 3: Digital education resources and platforms

The COVID-19 pandemic highlighted the challenges that many countries face in identifying, curating and distributing learning resources, pointing again to the need for policy to be responsive to the need for equitable access to quality learning resources. Many of the existing smart education policies across the ten countries highlight the value of investing in open educational resources (OER) and open education practices (OEP).

## Open education resources, open learning and open education practices

In the early stages of ICT adoption in education institutions across the world, policy attention was focused on investment in access to digital infrastructure, particularly devices and connectivity. These were often given priority over exploring how to use technologies appropriately for learning and teaching and developing teacher capacity to support optimal learning with technologies. While attention on physical ICT access continued, the focus on mapping digital content against national curricula became more pronounced. This led to the growth of an OER 'movement' which was accompanied by the development of dedicated national and institutional OER policies. These policies were either standalone national policies linked to ICTE policies or integrated into existing ICTE policies. OER come in a wide variety of formats: printed study notes, test preparation materials, question banks, learning videos, courses and course components, for example. They are underpinned by philosophical imperatives of open education and open learning, and pedagogical shifts ranging between behaviourism, constructivism and connectivism. UNESCO and COL developed guidelines for the development of OER policies (Miao et al., 2019). Open and inclusive collaborative engagements with stakeholders, evidence-based policy support and capacity-building are key factors in policy development and implementation (Mishra, 2020).

South Africa has adopted an open learning policy in post-school education. The Department of Higher Education and Training makes a commitment in the policy to support the production and sharing of OER in the post-school sector and will develop an appropriate open licensing framework that all education stakeholders can use within an overarching policy framework on intellectual property rights and copyright in the post-school sector.

China's Notice on the Recommendation and Selection of the Smart Education Pilot Zone Construction Project includes mechanisms for collaborative innovation to promote and supply OER across regions for equal and inclusive education as part of its broader adoption of AI and big data in the education project.

The USA's NETP is another example of a national ICTE policy that makes an explicit commitment to OER.

## Learning management systems, digital libraries, digital platforms

OER come in a wide variety of formats, including as printed learning resources or radio and television broadcast content, but they are often accessed via digital libraries or learning management systems (LMS), online applications that not only allow users to access education resources but also offer tools and applications that facilitate the tracking of learning. Egypt's well-known digital library, the Egyptian Knowledge Bank (EKB), for example, was established in 2016 and was used in 2020 to host all content for primary and secondary classes during COVID-19-related school closures.

China's massive digital education platform is the largest government-led public education platform in the world in terms of the number of registered users. In December 2012, the Ministry of Education officially launched the National Education Resource Public Service Platform to provide teaching and learning support resources for schools, teachers, students and parents. By the end of June 2018, it had registered 12.48 million teachers, 5.89 million students, 5.34 million parents and 400,000 schools. It was connected to sixty-five online platforms and had 68.6 million registered users, of whom 3.37 million were active (Hu and Zhang, 2020).

The rapid growth of data-driven platform software means platform technologies function increasingly as integral enablers of learning and learning and teaching resources. Sefton-Green et al. (2019) define a platform as a closed, programmable, proprietary online site that can be accessed across many different devices (from desktops to mobile phones) and that creates relationships, interactions and data about those interactions within its system. National policies articulate the goal to establish education platforms that span the full spectrum of learners and teachers and education communities at scale.



### Possible tensions and gaps related to digital education resources and platforms

Many ICTE and smart education policies do not (yet) make explicit references or commitments to the use of open educational resources and related open education practices. Investments in these are perceived to be at loggerheads with large-scale proprietary content investments. This issue has become more complex as some proprietary platforms are leveraging OER. The possible tensions relate to the extent to which OER investment will bring cost savings for governments without compromising on the quality of OER. While cost and quality of OER are reconcilable, they can also be sources of tension.

An added challenge that policies have not yet been able to address is the management of the growing array of private education platforms alongside public education platforms targeted at the same learners, teachers and education communities.

## Policy theme 4: Skills and competencies

One of the biggest policy challenges of the twenty-first century is for education systems to develop the skills required for an unequal, volatile, uncertain, complex and ambiguous (UVUCA) world that is confronting a climate emergency; is vulnerable to pandemics, crises and wars; and is lagging in response to the rapid diffusion of exponential technologies in daily life, including education, work and play. Various global agencies have released studies on how the changing skills demands of a 4IR labour market have influenced national education system policy approaches. Studies by the World Economic Forum (WEF) and World Bank, for example, show an increasing demand for advanced cognitive skills (critical thinking and problem-solving) and non-cognitive skills (creativity, curiosity and cooperation) that are transferable across jobs (World Economic Forum, 2020)

The ICTE and smart education policies in the current study all highlight the importance of being responsive to the needs of the rapidly changing labour market. For their vocational education and training (VET) and higher education (HE) systems, many countries have been developing competency-based education (CBE) systems, which reflects the view that post-school systems are primarily about addressing the skill requirements of the labour market and that curricula should be designed to meet these requirements. The USA's NETP for higher education states that its CBE is focused on an intentional and transparent approach to curricular design in which students acquire and demonstrate their knowledge and skills by engaging in learning exercises, activities and experiences that align with clearly defined programmatic outcomes. Learners earn credentials by demonstrating mastery through multiple forms of assessment, often at a personalized pace (Office of Educational Technology, 2017b).

The South Korean government launched its Free Semester Program (FSP) and the SMART Initiative to meet changing industrial demands and a desire to grow a creative economy through its national competency framework, which is also geared to equip students with the skills they will need for an emerging fourth industrial revolution (Jeong, 2020). The country's national AI strategy proposes to innovate the education system so that all citizens can make good use of AI and the country produces a consistent stream of world-class experts. It involves significant investment in building skills and capabilities systematically across the national education, training and lifelong learning systems.

India's national AI strategy anticipates that technologies will increasingly disrupt the nature of jobs and shift the benchmarks of technological aptitude, skilling and reskilling. The country proposes the promotion of job creation in new areas, like data annotation, to open up opportunities to the large portion of the workforce that may become redundant due to increasing automation.



South Africa's MTT's report on 4IR for the PSET system proposes a strong set of education and training programmes that align with the changing needs of both South African society and the world of work in the context of the 4IR. The report recommends that policy should promote access to high-quality educational opportunities to meet the burgeoning and immediate demand for digital skills in the labour market created by the 4IR and simultaneously create a new wave of South African innovators and entrepreneurs who will help to drive and shape the 4IR to the social and economic benefit of all citizens. It also recommends massive increases in short-course skilling opportunities for unemployed and underemployed South Africans in parallel with wider government and private-sector efforts to grow new employment opportunities for the unemployed and underemployed (DHET, 2019).

Egypt's national AI strategy proposes the development of lifelong learning and reskilling systems to encourage workforce development and sustained employability and to prepare the Egyptian population for an AI age.

Singapore's national AI strategy includes equipping all citizens with basic computing skills and computational thinking. This involves:

- making computer science part of all students' learning programmes in order to develop 'bilingual individuals' who can apply computer science and AI concepts in their respective domains. Students will be encouraged to learn basic foundational concepts to spark their interest in AI at an early age and develop basic AI competencies and literacy, and will have opportunities to explore AI applications in more during their higher education.
- developing AI-ready graduates by encouraging institutes of higher learning to introduce domain-specific AI courses so that undergraduates understand how to apply AI to their areas of expertise and are able to leverage AI tools in their work.
- training 25,000 professionals in basic AI coding and implementation by 2025.

The UK's AI strategy targets users of AI by proposing to engage employers and employees so that they can understand how they could use AI in their businesses. It proposes helping employers to identify their AI skills needs by using the Skills Value Chain approach that the UK Department for Education (DOE) developed. The Office for Artificial Intelligence will work with the DOE to explore how these needs can be met and mainstreamed through national skills provision. The DOE also plans to organize skills bootcamps in the form of free, flexible courses for adults so that they can develop sector-specific skills.

The UK Government has already embarked on a host of programmes and initiatives to address the AI skills gap. For example, by 2021, 2,500 conversion courses in AI and data science were being delivered through universities in England. These conversion courses provided students with the opportunity to develop new digital skills or retrain to help find new employment in the UK's cutting-edge AI and data science sectors. In addition, the UK strategy focuses on what the government calls 'those we want to be inspired by AI', which refers to its AI Council's Roadmap that identifies the value of inspiring people who do not yet use AI and exposing children to AI through support for its National Centre for Computing Education (NCCE) so that they can be inspired by the potential of AI. The UK's Office for AI will also work with the DOE on career pathways for those working with or developing AI, including the National Careers Service.

### Teacher, lecturer and faculty competencies and professional development

Numerous digital or ICT competency frameworks focused on teachers and lecturers have emerged as attempts to define critical competencies for teaching in a digital age. They include the UNESCO ICT Competency Framework for Teachers, the European Digital Competency for Educators (DigCompEdu), the ISTE standards for educators and the UNESCO IICBA ICT-Enhanced Teacher Standards for Africa as global or continental frameworks.

At a national level, several ICTE policies and emerging smart education policies include approaches to developing national teacher and lecturer digital learning/smart learning competency frameworks. The South Korean Government, for example, established a system to develop teachers' pedagogical competencies. Its SMART initiative provided not only guidelines and tools for teachers to use relevant platforms to support their teaching practice and professional development but also professional learning communities where teachers could find support. South Korea also established SMART Education Experience centres to provide hands-on experience to teachers and developed a tailored curriculum for pre-service teachers that incorporated new pedagogies aligned with the SMART Education initiative (UNESCO, 2019b).

The USA's policy recommends that the country build a teaching force skilled in online and blended instruction and develop a common set of technology competency expectations for university professors and teachers for teaching in technologically enabled schools and postsecondary education institutions.

South Africa's Department of Basic Education, in partnership with UNICEF South Africa, developed and adopted a Professional Development Framework for Digital Learning in 2018. This framework provides guidelines for the professional development of teachers, teacher educators, e-learning specialists and curriculum subject specialists who can facilitate the development of digital learning competencies for teachers. Digital learning competencies are defined via three domains, each of which has identified competencies and indicators. The three domains are teachers' professional growth and knowledge; a curriculum focus on using digital tools and resources appropriately and to their full potential for learning and for attaining curriculum objectives; and leadership in terms of demonstrating the vision for digital learning and accepting responsibility for its implementation and growth. The framework includes an online self-assessment tool for teachers to help them understand the competencies they still need to develop. The tool links competencies to professional development activities that are officially endorsed by the South African Council of Education (SACE).



## Student competencies

For the schooling and post-school systems, global frameworks that specify the digital skills needed by children and youth have emerged – for example, the eight digital skills needed by children (WEF, 2016), the OECD Learning Compass 2030 (OECD, 2018), and the Global Framework Reference on Digital Literacy Skills (UIS, 2018) – and include core foundations, knowledge, skills, attitudes and values, transformative competencies and a cycle of anticipation, action and reflection as well as the concept of student agency, student well-being and student co-agency with their peers, teachers, parents and communities.

The national case study policies highlight the importance of developing cognitive and non-cognitive competencies. For example, the NETP in the USA refers to social and emotional learning (SEL), which involves skills, habits and attitudes that facilitate functioning well in school, work and life: self-awareness, self-management, social awareness, relationship skills, perseverance, motivation and growth mindset (the understanding that abilities and intelligence can be developed), for example (Office of Educational Technology, 2017a).

## Student and teacher agency and co-agency

While there is no global consensus on the notion of agency for students and teachers, the concept features in some national policies. The USA's NETP identifies learner agency in K–12 education as a person's ability to play a part in their self-development, adaptation and self-renewal with changing times (Office of Educational Technology, 2017a). Its higher education policy further recognizes that with 74% of its undergraduate students having at least one non-traditional characteristic (such as being a first-generation student), student success is determined more by the ability to navigate structural institutional constraints than by academic potential. Thus, student agency requires an enabling system and institutional environment that will help students to overcome structural barriers.

The OECD defines student agency as relating to the development of an identity and a sense of belonging. When students develop agency, they rely on motivation, hope, self-efficacy and a growth mindset to navigate towards well-being. This enables them to act with a sense of purpose, which in turn helps them to flourish and thrive in society. Students are agents in their learning, they are more likely to have 'learned how to learn' – an invaluable skill that they can use throughout their lives. Co-agency is defined as interactive, mutually supportive relationships – with parents, teachers, the community and each other – that help students progress towards achieving their shared goals (OECD, 2019).

## Learner community-building

Building community among learners is not a new concept, as shown by Rovai (2002). However, it has been gaining traction alongside the ongoing integration of digital technologies with learning and teaching and the resurgence of remote learning during the COVID-19 pandemic. The idea of community-building is based on the value of social bonds in learning and how these can be enabled and supported by digital technologies. Community-building engenders mutual trust, connection and belonging and is premised on social interaction among learners as peers and between learners, their teachers and their parents or guardians. Community of practice is part of digital learning and ICTE policies, based on the notion of sharing purposeful patterned activity, drawing on the communities of practice work by Lave and Wenger (1991). In this context, leveraging the capabilities of technologies to promote learner community-building is another step towards fostering learner agency.

## Targeted development of STEM skills to meet industry needs

National AI strategies have also tended to emphasize the need to develop skills and capabilities in science, technology, engineering and mathematics (STEM) skills, encourage future computer scientists and mathematicians and establish AI campuses. The Mauritian national AI strategy plans to encourage the training of computer scientists and mathematicians in the medium term and to create an AI campus that would target specified numbers of students and deliver tailor-made programmes over short periods so that students can be deployed to relevant economic sectors. It also details plans to review existing elective modules at universities and to make computer programming and coding mandatory for all fields of study. This recommendation is also linked to making available scholarships for advanced training in AI to locals and to foreign students in Mauritius. In addition, Mauritius is promoting STEM literacy, and increasing digital science and AI training in high schools and universities. A consistent supply of graduates in AI-related fields would be built through the democratization of science and the promotion of careers in the mathematical sciences from the primary school level.

India's strategy identifies the need to reskill and train its workforce through incentives, tax breaks and grants for employers. The skilling and reskilling of employees are linked to monitoring existing jobs that may be under threat because of AI. They are also linked to the creation of future jobs through incentives such as tax holidays or inclusion in corporate social responsibility with associated tax incentives.

## AI talent pool and talent management

The case study countries that have developed national AI strategies also commit to establishing and growing their respective national talent pool and managing talent development in AI and related exponential technologies. China's national AI strategy commits to, for example, improving the AI education system and accelerating the creation of world-class talent in the AI sector. Egypt's strategy aims to make Egypt a regional hub for AI education and talent serving local, regional and international market needs, and promotes the establishment of new, dedicated faculties of AI in universities such as Kafr El Sheikh, Monoufeya and the Arab Academy of Science and Technology. India's strategy includes a target to produce the requisite talent pool to drive innovation in emerging technologies.

The Mauritian national AI strategy highlights the need to identify and import talent from abroad. The Mauritian economy and labour market need people with skills and expertise in AI research, the design of applications and the use and adoption of AI systems in business. In the short term, the strategy recommends that expertise be imported via the Mauritian Diaspora Scheme and Innovators Occupation Permit, which were established to attract foreign expertise and specialists. It also includes the introduction of a 'talent watch' to determine the industry's AI skills needs with a view to matching training to employment and subsequently stronger dialogue and linkages between industry and education institutions.

Singapore's national AI strategy proposes to attract top-tier global AI talent from around the

world and develop local capabilities by mentoring emerging AI researchers and engineers and growing global talent networks.

South Korea's national AI strategy involves providing various channels to nurture AI professionals, including short-term intensive curricula as non-degree courses and industry-specific customized curricula, based on collaboration with industry.

The UK's strategy proposes to grow the skills, talent and capabilities to build AI systems by training and attracting the brightest and best people at developing AI. To meet the demand seen in industry and academia, the UK Government plans to continue supporting existing initiatives and programmes, such as Turing fellowships, centres for doctoral training and postgraduate industry-funded master's and AI conversion courses.

### Recognition of skills: Microcredentialing and lifelong learning

How national governments and their institutions recognize learning and skills development is a topic of debate in education systems across the world. The recognition of informal, non-formal and formal learning as part of an endeavour towards lifelong learning has surfaced in the context of the possibilities that digital and exponential technologies can offer. These technologies have enabled the increasing accessibility and rapid development of a growing number of online resources (experts, videos, apps, communities, etc.) and in so doing have shifted the boundaries of possibility for learning, teaching and qualifications. UNESCO and other organizations have highlighted these shifts and made attempts at coordinating an entirely different context for teaching and learning for both educators and their students (Chakroun and Keevy, 2018).

While the concept of microcredentials is not new, it has evolved in recent years to become an umbrella term that encompasses various forms of credential, including "nanodegrees", "micro-masters credentials", "certificates", "badges", "licences" and "endorsements" (Chakroun and Keevy, 2018, p. 10). Microcredentials have also become synonymous with certificates of assessed learning earned through the major MOOC platforms, with many providers adopting their own labels – for example, MicroMasters (EdX), Nanodegree (Udacity) and Specialization (Coursera) (Brown et al., 2021). The national case study policies are less explicit about microcredentialing, although they highlight commitments to developing lifelong learning systems.

### Building AI awareness and competencies for all

With the emergence of more advanced technologies like AI, some countries have developed national AI strategies and have already begun to invest in growing AI competencies for their citizens. For example, Singapore has made available an AI for Everyone (AI4E) programme to help familiarize citizens with AI and help them understand how they can use AI in their daily lives. It includes scaling AI literacy courses to 100,000 adult Singaporeans and school-going children by 2025.

Egypt's strategy is to raise public awareness of AI, its uses, benefits, risks and limitations so that citizens are educated, knowledgeable users of AI systems. Similarly, Mauritius has AI-sensitization campaigns among Mauritian citizens, businesses and government officials.

South Korea's national AI strategy calls for raising public awareness of AI to create an opportunity to grow national capabilities. The plan is to eradicate digital illiteracy and enhance awareness of AI in the public sectors by making AI literacy education mandatory for new and promoted public officials — the aim is to train at least 1,500 people per year in this way. The government also proposes having mandatory AI training at industrial sites for employees in every industry, including small and medium-sized enterprises (SMEs), venture companies and industrial complexes, and developing industry-specific AI training programmes focused on improving the work proficiency and productivity of field workers.

To ensure that policies promote ethical design, there have been calls to actively involve learners, teachers, parents and communities in the design of technologies and open algorithms that can be verified by third parties (OECD, 2021).



### Possible tensions and gaps related to smart education skills and competencies

The skills and competencies outlined in national ICTE and smart education policies have also brought to the fore debates about the human capital, labour market-centric approach to skills development and have highlighted the importance of prioritizing values-based and life skills to combat inequality, discrimination and unethical values in emerging AI systems. Current policy gaps in this area will need to be addressed more rigorously.

The microcredential issue has also revealed tensions arising from concerns about the rigour and quality of microcredentials and the diverse organizations that are offering them and how microcredentials can fit into existing compensation systems. These issues are likely to be ongoing and policies will need to address them in the coming years.

## Policy theme 5: Governance

Most national policies identify with the premise that the use of data and analytics adds value to education systems, especially in terms of creating opportunities for ‘precision’ in diagnoses and support for flexible learning, teaching, education management, administration and decision-making practices in real time. Investments in AI-based machine learning systems that enable the processing of large volumes of data have the potential to increase data access, democratize decision-making, make institutions more ‘transparent’, and increase accountability of institutional and system leadership and management.

Thus, the governance of data in education systems is becoming an increasingly central policy consideration alongside the proliferating datafication of education systems across the world. The datafication of education comprises the collection of data at all levels of educational systems (individual, classroom, education institution, districts, regions, states, national and international), potentially about all teaching, learning and school management processes. It influences decision-making, opinions, and relationships between education stakeholders.

However, there are also emerging governance risks associated with the datafication of education. Traditional ethical and legal frameworks have been challenged to keep pace with the rapid changes in the more recent quantum technological paradigms.

While the potential for misusing data of education stakeholders, especially children, is a source of concern, the issues are complex, and the gravity of the complexity is not necessarily reflected in current policies or grasped by policy-makers (Corrin et al., 2019).

Some of the case study policies do attempt to address data governance challenges. The Mauritian national AI strategy makes explicit recommendations related to the governance of AI systems and their integration in education, training and priority economic sectors. It highlights the need for the Mauritian Government to develop an appropriate legal and regulatory framework and to build public trust by protecting the privacy and safety of citizens’ data. In this respect, the report acknowledges that the existing legal frameworks may be limited and may constrain the expansion of a research and development (R&D) and innovation culture in Mauritius. It proposes that the country’s intellectual property (IP) rights laws be revisited; that the necessary data protection legislation be addressed by a special working group; and that the passage of a new intellectual property bill be expedited. It further recommends that, where AI solutions are developed with private developers, the solutions should remain the intellectual property of the developers, even if they received government support. At the same time, it also

notes that the legal framework will need to ensure that human decision-making can override AI-based decision-making.

Singapore's national AI strategy proposes to provide a top-class IP regime and accelerated patent initiatives for AI – that means that AI companies seeking to grow and expand internationally will need to develop a clear intangible asset (IA) and IP strategy. To support companies, the Intellectual Property Office of Singapore (IPOS) launched a new enterprise engagement arm, IPOS International, to provide them with customized IA solutions and programmes.

## Cybersecurity risks

The governance of educational data and datafication requires effective responses and mitigation strategies to deal with both the actual and the potential risks, including exploitation and abuse, that the internet and exponential technologies pose to the health, well-being and safety of children, youth, adults, and education communities. Some policies highlight how crimes against children and youth, and the tactics used to ensnare the perpetrators, are becoming more sophisticated. There have also been increasing reports of bullying and its digital counterpart, cyberbullying. Some national policies have supplementary guidelines on safety and combatting bullying and cyberbullying.

However, new risks are also emerging in the face of exponential technological systems such as AI. They include algorithmic forms of bias and discrimination; the automated reproduction of inequalities and disadvantage; regimes of data-centred surveillance and algorithmic profiling; disregard for data protections and privacy; political and commercial microtargeting; and the power of technology corporations to control and shape all sectors and spaces they penetrate, from whole cities and citizen populations to specific collectives, individuals or even human bodies (Whittaker et al., 2018). Another emerging risk relates to cyber-attacks on digitized education management systems in schools in the form of malware and ransomware, which appear to have escalated during the COVID-19 pandemic in countries like the USA. US public schools have reportedly experienced 1,600 cyber-attacks since 2016, including one in January 2022 when administrators in the Albuquerque school district were blocked from accessing the district's student database (Melia and Suderman, 2022).

The predominance of private governance systems in education through private companies that own digital platforms and applications and the roles that they assume as regulators also pose a growing risk to the governance of public education systems. They could potentially also weaken public governance systems.

Existing ICTE and smart education policies are limited in their strategies to mitigate these and emerging risks. Generally, policies refer to the aspirational need for more trustworthy, humane, human-centred, safe systems in education. Some governments have, however, taken steps towards legislating against cyber-attacks in schools – for example, the USA signed the *K-12 Cybersecurity Act* into law in 2021 (US Congress, 2021). This act identifies, among other things, the risk of the possible disclosure of sensitive student and employee information that is stored and managed on K–12 education institution information systems. It identifies the following as sensitive information:

- student grades and information on scholastic development
- medical records
- family records
- personally identifiable information

To address these cybersecurity threats the act recommends that:

- the Cybersecurity and Infrastructure Security Agency (CISA) develops cybersecurity guidelines that can be used by K–12 education institutions on a voluntary basis,
- CISA evaluate the challenges schools face in securing sensitive information and their information systems,
- an online training toolkit targeted at K–12 education officials be made available on the US Department of Homeland Security website, and
- education officials receive training in cybersecurity recommendations.

The risks and dangers inherent in the escalation of more advanced technological systems such as AI pose a host of regulatory and legal challenges for a human rights framework. For instance, the USA's NETP highlights that privacy is a legal principle and a basic human right that relates to the right to freedom from surveillance or unauthorized disclosure of personal information. It refers to the need to revise practices, policies and regulations to ensure privacy and information protection while enabling a model of assessment that includes ongoing gathering and sharing of data for the continuous improvement of learning and teaching. The NETP also includes cybersafety and cybersecurity training for students, teachers, and parents as part of district and school 'responsible use' training.

Other global frameworks have also emerged to support the protection of children, youth and education stakeholders in a digital world – for example, the UNICEF (2018) Children's Online Privacy and Freedom of Expression Toolkit for Industry, and the ITU (2020) Child Online Protection Guidelines.

### Ethics and responsible AI

The integration of ethical principles in smart education policies is still an emergent phenomenon as governments and education stakeholders work to make sense of the ethical implications of rapidly diffusing technologies in education. Numerous general ethical frameworks and professional codes of conduct have been developed to frame the risks and dangers of AI in society and strategies have been developed to mitigate them.

Most are transversal in their approach and not specific to education systems. At a global level, in November 2021, UNESCO Member States adopted the Ethics of Artificial Intelligence which aims to both realize the advantages of AI to society and manage the risks associated with its adoption. UNESCO takes a human rights approach to AI ethical issues, with a focus on how AI can contribute to the achievement of the Sustainable Development Goals by confronting challenges of transparency and accountability. It provides action-oriented policy recommendations on data governance, education, culture, labour, health care and the economy (UNESCO, 2021b).

At a national level, Singapore's Smart Nation strategy makes explicit reference to an awareness of new ethics and governance challenges that will be caused by the disruptive effects of AI both in general and in education. It calls for a balanced and pragmatic approach to build a trusted ecosystem to drive AI development and adoption. Its Infocom Media Development Authority published a discussion paper (IMDA, 2020) on what an AI governance framework might look like and set up initiatives such as the Advisory Council on the Ethical Use of AI and Data – to promote responsible development and deployment of AI by businesses – and the Research Programme on the Governance of AI and Data – to develop local capacity to understand and mitigate AI risks. All of these are likely to inform ethically appropriate approaches to AI and related technological adoption in Singapore's education system.

Similarly, Scotland, in the UK, developed an AI strategy with a strong focus on promoting trustworthy, ethical and inclusive AI in ways that take into account the needs and preferences of its citizens. Scotland's AI strategy also recognizes the specific challenges and opportunities

AI presents for children. The country adopts UNICEF's Policy Guidelines on AI and Children where they focus on AI policies and systems that protect children, provide equitably for their needs and rights, and empower them to participate in an AI world by contributing to the development and use of AI. Egypt's national AI strategy also commits to activity contributing to global efforts to manage AI ethics, responsible AI and the social and economic impact of AI.

### Responsible digital citizenship, digital well-being and responsible machine learning principles

Several policies promote responsible digital citizenship in response to the risks to privacy, security and ethics. Responsible digital citizenship also means encouraging greater agency among students, teachers and education communities to protect their data (Prinsloo and Slade, 2016) and holding accountable stakeholders who are identified as, or likely to be, transgressors.

While national smart education policies offer less detail about strategies to mitigate the risks and dangers associated with exponential technologies and their diffusion through education systems, regional and global transversal principles and frameworks that are focused on minimizing risks, designing conscious and ethical approaches for educational designers and holding them accountable are emerging in ethical use of AI and responsible machine learning principles.

Singapore's national AI strategy proposes to win citizens' trust about the responsible use of AI. To this end, the Singapore Government has established the industry-led Advisory Council on the Ethical Use of AI and Data. The council advises the government on issues arising from the commercial deployment of AI that may require policy or regulatory attention and advises industry on the responsible development and deployment of AI. By 2019, it had developed its first Model AI Governance Framework which provides detailed and readily implementable guidance to private sector organizations to address key ethical and governance issues when deploying AI solutions. In addition, it will develop sector-specific AI governance frameworks, including codes of practice and professional codes of conduct for different sectors and application contexts:

- Curate technical solutions that enable explainable AI that industry can use to augment its AI models.
- Develop training and certification in AI ethics and governance for professionals who manage AI solutions and implement AI projects, which will be overseen by the Singapore Computer Society's newly formed AI Ethics and Governance Steering Committee.
- Publish assessment guides for organizations to assess the alignment of their AI governance processes with the Model AI Governance Framework.

A key feature of the South Korean AI strategy is that it pays significant attention to the notion of creating trustworthy AI by preventing dysfunction and establishing AI ethics. The measures include:

- leading the global discussion on ethics and AI, including about efforts to prepare the follow-up measures of the OECD's Recommendation of the Council on Artificial Intelligence;
- conducting R&D in order to develop new services and prevent dysfunctions resulting from AI development, and establishing an inter-ministerial cooperative system; and
- establishing a quality management system that verifies reliability and safety in response to the proliferation of AI products and services.

The UK's AI strategy pays attention to the need to develop the ethical design and use of AI systems. The government set up the AI Council to explore ways to encourage the ethical and responsible approaches to AI.

India's national strategy stresses the importance of privacy as a fundamental right and states that 'the protection of this right with its multiple facets in a fast-changing technological environment will not just depend on State enforcement, but by also making the citizens aware of their rights and how they can protect them' (NITI Aayog, 2018, p. 88). The document states that the inclusion of privacy rights in school curricula can serve as a way to spread awareness about the importance of consent and data ethics. In such cases, awareness-raising could be complemented by clear requirements and regulations for users and providers to ensure privacy protection (UNICEF, 2020).



### Possible tensions and gaps related to smart education policy and governance

Existing ethical and legal frameworks are challenged by the rapid adoption of artificially intelligent exponential technology in education and beyond. In fact, the legal and regulatory frameworks are insufficient in all respects to deal with the pace of adoption and its consequences.

Moreover, important debates persist about the way legal frameworks that do not protect private citizens do protect powerful commercial interests (Greene et al., 2019) and that there are multiple, often conflicting stakeholder interests at play. In this respect, the aspiration to protect the privacy of citizen data may be severely compromised in the face of data-extractive cultures of machine learning and AI technologies and the way they are designed.

The education policy space is therefore increasingly challenged in the sphere of governance and exponential technologies, which will be a major preoccupation of emergent national AI institutes across the world. The prevalence of gaps in existing policy and regulatory frameworks was noted in the *Governance of Data for Children's Learning in UK State Schools* report, released by the UK Government in July 2021. The report highlighted significant regulatory and implementation gaps in the existing data governance framework, including legal and practical difficulties faced by schools, regulators, EdTech businesses and families (Ash-Brown, 2021).

The literature also suggests that policy will need to influence and guide the design of these data-intensive algorithmic technologies in education to ensure that they are safe, secure, ethical, empathetic, equitable and inclusive. Reich et al. (2021) suggest that technologists and programmers at big corporations and start-up companies need to be lobbied on designing such appropriate technologies. Public policy will therefore need to play a role in the accountability of technologists, designers and programmers in terms of prioritizing equity, non-discriminatory and inclusion considerations and design algorithmic systems that are safe, inclusive, humane, ethical and environmentally sustainable.

## Policy theme 6: Educational management and administration

ICTE and smart education policies have the efficient and productive management and administration of the education systems at all levels, from institutions to national systems, as a stated priority. Data-driven education management and information systems (EMIS) support the collection, processing, analysis and real-time dissemination of relevant education-related data to decision-making stakeholders such as teachers, parents, administrators, managers and governing bodies. With the increasing prevalence and development of data-intensive, algorithmic, precision technologies, institutional and national EMIS investments are central educational technology investments. The evolution of South Korea's National Education Information System (NEIS) provides a worthwhile case study of the influence of more sophisticated EMIS technologies over time. It started in 2001 by collecting data for

administration purposes. Over time it expanded to include human resource records at a national level and accounting; by 2013 it was streamlining student records and exam management and being used for engagement with parents, supporting student admissions and systematic workflow management.



### **Possible tensions and gaps related to smart education policy and management and administration**

The use of data via AI-powered EMIS systems continues to face ethical issues related to collecting, using, storing, mining and protecting personal and private data about learners, teachers and general education institutional staff. Finding appropriate, safe, ethical ways to collect, store, manage, and use personal data will be on the education policy agenda for the foreseeable future.

## **Big data and EMIS**

The introduction of big data technologies and educational data mining have enabled the growth of precision administration and management of education systems at both institutional and system-wide levels. They are used for managing admissions, timetables, attendance and homework monitoring, school inspections, machine learning-based dropout early warning systems, interactive visual dashboards that provide real-time, accurate data that enable precise decision-making and what big data can contribute to policy implementation monitoring. While the national ICTE policies of Singapore, the USA, the UK and South Korea make explicit commitments to continuously improving data-driven decision-making, national AI strategies are more explicit about the possibilities offered by AI-powered big data in education. For example, the national AI strategy of India proposes to invest in AI tools that can assist in automating teacher postings and transfer systems, using analytics based on demand-supply gaps across schools.

## **Enabling policy implementation**

One of the key lessons from the past two decades of education reform related to ICTE, and more recently smart education policy, is that beyond policy formulation and adoption, policy implementation is critical to systemic education improvement (Fullan, 2018; Harris and Jones, 2017). Many policy frameworks in ICTE to date have focused on policy adoption as an important steppingstone in creating a national enabling environment for the adoption of educational technologies. More attention is needed, however, on frameworks that can support and guide national policy implementation on ICTE and smart education. In this respect, it is important to frame policy implementation plans with timelines, resources, responsible units, etc., as Harris and Jones (2017, p. 202) found that even if a policy was well thought through, borrowed, adapted or copied wholesale, the implementation process deployed directly affected the outcomes and impact, and the same strategy implemented in very different contexts results in highly variable outcomes and impact. For example, South Africa's Ministerial Task Team (MTT) on 4IR for the PSET system report states explicitly that one of the systemic challenges the policy needs to address is policy implementation failure (DHET, 2019).

## Policy and strategy implementation masterplans

The case study ICTE and smart education policies are accompanied by high-level and detailed plans for implementation, sometimes referred to as masterplans. The more widely known ICTE masterplans are those developed by Singapore and South Korea, over successive five-year planning periods beginning in 1997. The latter has also been widely analysed over time (Jeong, 2020; Natarajan et al., 2018). The collective experience of implementing ICTE policy across all ten case study countries revealed key success factors for effective, inclusive policy implementation in ways that enable shared ownership across all stakeholders.

A few of the national AI strategies include references to national planning and implementation processes to achieve policy and strategy objectives and goals. For example, Egypt's strategy proposes an overall phased implementation over several years and includes a stated operating model for the first phase of the plan from 2020 to the end of 2022. The first phase identifies key initiatives in each of the four pillars, including the Capacity Building (AI4H) pillar, which align with the capacity-building plans outlined in the strategy. The strategy also proposes a framework based on the Explore Plan and Execute (EPE) Framework, which involves categorizing various initiatives according to whether they are at an explorative stage, a planning phase or at the execution stage.

### Planning and establishing specialized implementation structures and agencies

Established specialized agencies fulfil a variety of roles including national coordination, leadership and management of ICTE implementation. Sometimes these institutions have also specialized in conducting research and developing appropriate ICTE models. The British Educational Communications and Technology Agency (BECTA) in the UK, which was closed by the UK Government in 2015, was a good example of the latter. Some masterplans refer specifically to the formation of such agencies.

The development of national AI strategies creates the need for specialized agencies and institutes to lead and drive their conceptualization, design and implementation. For example, Mauritius's strategy report recommends that a Mauritius Artificial Intelligence Council (MAIC) be established to spearhead and drive the country's AI strategy. MAIC's responsibilities include coordinating, implementing and monitoring innovative projects in partnership with relevant stakeholders. In South Africa, the president established a 4IR Commission, which focused on exploring the establishment of institutions to promote human capacity and leadership in 4IR. The Egyptian government established a National Council on AI to implement and govern its AI strategy, including a dedicated focus on AI ethics.

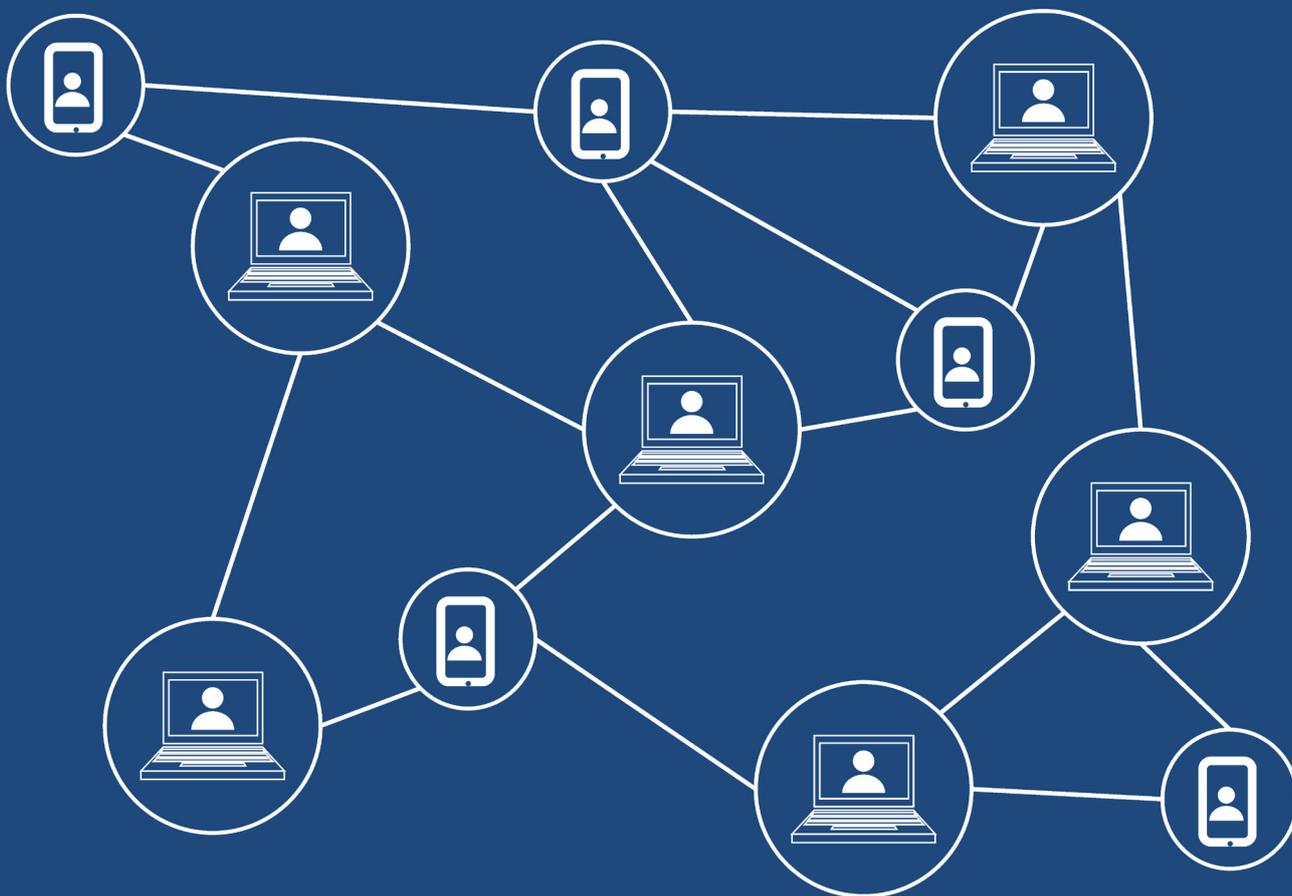
Russia's ICTE policy states an aim to establish a federal centre for digital education transformation, to create a centralized federal platform that would compile information on services in education, to increase the provision of online courses and to digitalize education administration and federal support for an increasing number of in-school and extracurricular activities related to teaching ICT (Piattoeva and Gurova, 2020).

## Leadership, system strengthening and change management

Harris and Jones (2017) highlight the point that education systems must have sufficient capacity to deliver and establish implementation processes and systems.

### Leadership and leadership development models

The success of the design and implementation of ICTE and smart education policies has proven to be dependent on the strength of the system's leadership. This is also reflected in the literature. The study of seven education systems by Harris and Jones (2017) found that education systems that had effective leadership and leadership development capacity have tended to demonstrate more improvement in education. Various ICTE policies indicate respective leadership models



to guide and lead policy implementation. In the USA's NETP 2017, a stated goal is to embed an understanding of technology-enabled education within the roles and responsibilities of education leaders at all levels and to set state, regional and local visions for technology in learning. The policy also identifies four key focus areas of effective leadership: collaborative leadership, personalized student learning, robust infrastructure and personalized professional learning.

Singapore's successive ICTE masterplans also focused on developing leadership at all levels, particularly at an institutional/school level. Their stated school leadership development programmes include:

- online courses and discussion for school leaders and teachers,
- learning journeys,
- lectures by thought leaders,
- school leaders being trained as facilitators and collaborators, and
- school leaders' reflections online and participation in social media.

### Managing large system change

Because national ICTE and smart education policies involve catalysing far-reaching, large systems change, the systematic management of these changes requires leadership capability in managing large system reform and policy implementation. Many ICTE masterplans focus on the 'what' of implementation and some articulate commitments to building capabilities to manage the 'how' aspects of catalysing and leading change. However, in general, ICTE and smart education policy implementation processes pay less attention to change leadership and change management capacity and systems.

Harris and Jones (2017), in their study of leadership across seven education systems, found that larger education systems have tended to manage change centrally by using top-down strategies and a culture of monitoring and compliance. Because of their size, the large systems also tend to demonstrate more variation, with some regions and districts having a strong capacity to manage change and others less so. This compares with smaller systems such as in Singapore where change is distributed to local institutional leadership levels and there is less variation across regions and districts throughout the country.



### Tensions related to policy problem formulation

The tensions related to leading policy implementation that are likely to emerge will stem from unanticipated, sharp and sudden changes and events that require agility in responsiveness. This is challenging when systems are not in place to manage both unanticipated shifts and changes that will accompany policy interventions in ICTE and smart education. Clarifying effective contextually relevant change management strategies remains a significant gap in policy design and implementation.

## Partnerships, finance and resource mobilization

Commitments to creating and sustaining multistakeholder partnerships are expressed in various national ICTE policies. As policy statements, the commitments are to leverage strategic alliances and to engage stakeholders in shaping ICT integration in education. They are often also a commitment to strengthen private sector engagement in the funding of ICT in the education system.

A host of partnership models have emerged in recent years. They include school community learning partnerships, the OECD's *Successful Partnerships: A Guide* (2013) and the public school partnership model being tried in South Africa (see *Public School Partnerships*, 2016).

All ten case study country policies on ICTE and smart education highlight the centrality of partnerships as part of a resource mobilization approach. In the USA, partnerships are central to securing resources from local businesses and other organizations; using alumni, internal and teacher experts to provide professional development; and developing curriculum development arrangements with districts, for example. Some school districts have formed partnerships with local and county governments to share technology infrastructure and technical staff and keep costs down by jointly funding chief technology officer roles and taking advantage of economies of scale when building and purchasing broadband access together. Such economies of scale have also been realized through consortium purchasing. In some cases, partnerships between academia and industry also enable research collaboration, with a recent example being the collaboration between academia and industry to develop vaccines for COVID-19. Korea's policy focuses on establishing an ecosystem to support students, teachers and parents and promoting partnerships with local government and the private sector.

### Financing and funding

Financing and funding are often stated in broad terms in ICTE policy and at a high level in policy implementation plans and masterplans. Total cost of ownership (TCO) models have been developed more broadly to guide governments on how to cost and budget for investments in ICT in education institutions. TCO considers all costs, including direct and indirect costs for the design, implementation, ongoing iteration, and improvement, maintenance and extensive use of a given digital learning innovation for sustainable development. TCO models that have been developed to date include the one for the ICT for Rural Education (ICT4RED) initiative in South

Africa and the TCO model in schools in the USA. TOC models consider the most significant cost factors to consider in varying contexts, from under-resourced and resourced contexts and varying innovations.

Korea's Smart Education policy provides a model for how financial investments are stated in policy. It shows an average operation cost per school for elementary, middle and high schools as well as an ICT in education budget classification per school sector based on a survey conducted by the Korea Education and Research Information Service (KERIS).

By February 2005, the Korean Ministry of Education had developed a local education administration and finance system now known as EDUFINE. EDUFINE's main objective was to reflect on and incorporate user feedback, reduce redundant work, provide transparency in regional education's finances, and improve the efficiency and safety of the online administration and finance system. One of its major accomplishments was the creation of a one-stop system for budgeting and execution of the implementation plans. As a result, regional education offices' and other pertinent local education institutions' budget and accounting workloads have been drastically reduced. Also, the transparency of budgeting and accounting has been vastly improved, and EDUFINE's one-stop business transaction capabilities prevent possible corruption and/or backhand dealings (Hwang et al., 2010).

## Resource mobilization

Resource mobilization and fundraising strategies are often referred to at a high level in ICT4E policy. Sources of funding and investment in ICT in education institutions are usually based on state budgets for education. In addition to having dedicated budgets to support ICT integration in education institutions, attempts have also been made to mobilize resources from ICT and finance ministries and to establish partnerships with aid and development agencies and private companies. Universal service funds have historically provided a basis for ICT investment in education institutions. More recently, start-ups and partnerships with commercial companies have served as additional strategies for mobilizing resources to finance policy commitments in ICTE and smart education.

## Evaluation, research and innovation

Monitoring ICT use in education and evaluating whether and to what extent they improve access to and the quality of learning and teaching have become increasingly strategic and important in national ICTE policy design and implementation. Emerging smart education policies also make commitments to ongoing improvements and system learning by investing in monitoring and evaluation (M&E) of major ICTE interventions that emerge from those policies. Egypt's AI strategy proposes a phased implementation process in which M&E is integrated.

Such evaluations have been applied systematically in Singapore and South Korea, where successive ICTE policies have been the outcome of systematic evaluations of policy implementation over time. In Korea, the focus was to measure changes in students, especially through the use of digital textbooks as part of the SMART Education initiative. These evaluations reportedly demonstrated improvements in learning and the development of relevant skills and competencies. They also triggered debate among stakeholders about the adverse effects of digital addiction (Jeong, 2020).

## Investment in AI research

In addition to integrating monitoring and evaluation in implementation masterplans and strategies, research features particularly strongly in the smart education policy space. Investment in research and AI research institutes and in developing smart and AI research agendas is a prominent topic of interest.



- The government of Minhang District formulated and implemented the Plan of Creating a National Smart Education Pilot Zone in Minhang District, which includes an exploration of the regional ICT public service system of collaborative innovation in production, learning and research.
- Egypt's AI strategy includes plans to prioritize AI research in the spheres of both basic and applied research by increasing AI research funding through local and international funding agencies and to track the research accordingly. The strategy involves actively recruiting PhD students who are studying abroad to return to Egyptian universities and to recruit renowned Egyptian expatriate researchers to assume visiting positions at newly established centres for AI research in Egypt. The country also plans to build linkages between Egyptian universities and specialized research centres internationally.
- The UK's AI strategy also proposes an ambitious agenda for AI R&D, including a £46 million investment in Turing AI fellowships to attract, recruit and retain a substantial cohort of leading researchers and innovators at all career stages.

### Research partnerships

Some national ICTE policies highlight the importance of developing research partnerships between academia, industry and government. The UK Strategy for Education Providers, for example, emphasizes the need for research to fill predicted gaps in educational technology products for the education market. It also expresses a need to evaluate whether or not technologies are having positive educational and economic effects and to gather evidence of good practice more systematically and share them more widely.

### Research accelerators and evidence intermediaries

Policies are also noting the need for and use of emerging research accelerators and evidence intermediaries. These are dedicated companies and institutions that research educational technology products to promote their use in the education market. The UK Strategy for Education Providers cites a few case studies of research accelerators and evidence intermediaries that have used evidence and evaluation to help EdTech companies align their products with the needs of the education market, including education institutions, schools, educators and

students. Research accelerators and evidence intermediaries also help build relationships between small and medium tech enterprises, start-ups and education institutions. Part of their work is the establishment of ‘test-beds’ and ‘demonstrator’ schools and colleges to exemplify how technologies can be used to best effect.

### Smart education research institutes and AI Centres of Excellence

National AI strategies to date have included commitments to establish dedicated research institutes and centres to continuously explore new and emerging frontier technologies in education. Scotland has two dedicated AI Centres for Doctoral Training and three institutions that include elements of AI. The Industrial Centre for Artificial Intelligence Research in Digital Diagnostics (iCAIRD) is a pan-Scotland collaboration of fifteen partners from across industry, the National Health Service (NHS) and academia. With funding from Innovate UK and key industrial partners, iCAIRD is building a world-class Centre of Excellence focusing on the application of AI in the field of digital diagnostics.

Similar institutions are espoused in the national AI strategies of Russia, China and Singapore. In South Africa, commitments include the establishment of data science centres. As noted earlier, Egypt’s national AI strategy proposes to woo back PhD students who are studying abroad and recruit some renowned Egyptian expatriate researchers. It also aims to establish new centres for AI research and to link universities or research centres in Egypt with corresponding specialized entities internationally.

India’s strategy includes an ambitious AI research agenda that involves promoting AI research and applications by establishing Centres of Research Excellence (CORE) for AI and International Centres for Transformational AI (ICTAI). It also states a goal to create a specialized research centre for AI along the lines of the European Organization for Nuclear Research (CERN) by bringing together other interested national governments.



#### **Possible tensions and gaps related to evaluation, research and innovation.**

Anticipated tensions in the evaluation, research and innovation space are likely to arise from the strong market-oriented focus of research agendas and a potentially limited focus on issues of non-discrimination, ethics and equity and inclusio

# Chapter 5

## National smart education policies and case studies



## National smart education policies and case studies

This section provides a brief policy discourse analysis of the emerging smart education policy texts in each of the ten case study countries. It builds on numerous toolkits and policy analyses of ICTE policies and masterplans in the extant literature. Because of the attention to education system policy responses to emerging fourth industrial revolution (4IR) and exponential technologies, the focus is on policy texts in more recent transversal government policies and strategies on AI or on dedicated smart education or 4IR in education reports that serve to inform future policy development. Where explicit 4IR and smart education policies have not been developed, the most recent ICTE policy texts are analysed.



## People's Republic of China

**Table 5. Basic demographic and education system information about China**

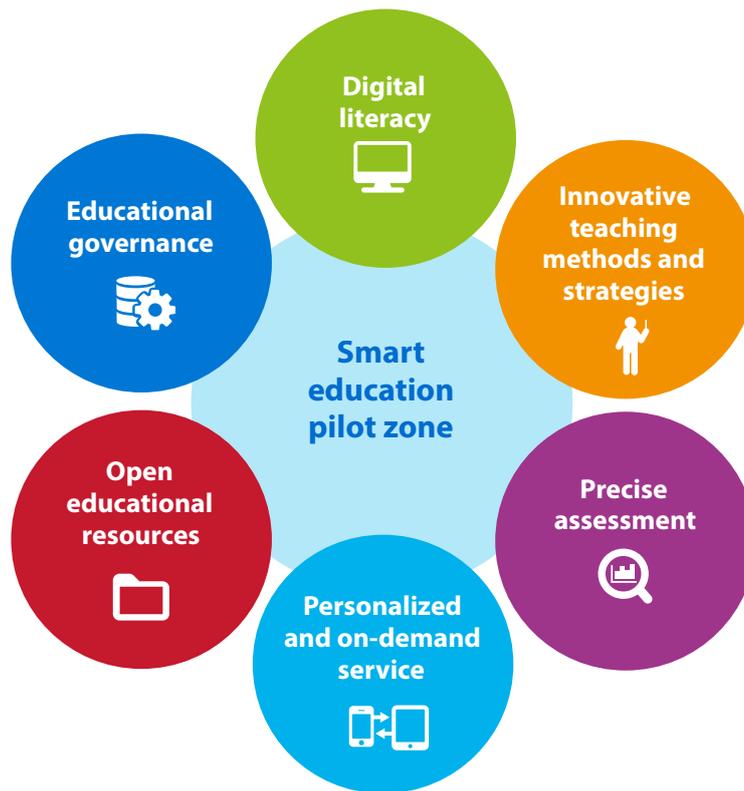
<b>Population (August 2021)</b>	<b>1 445 526 800</b>
<b>Historical ICTE policies</b>	Ten-Year Development Plan on ICT in Education 2011–2020 (2012)
	13th Five-Year Plan for ICT in Education (2016)
	Education Informatization 2.0 Action Plan (2018)
<b>Smart education-related policies</b>	Education Modernization Plan towards 2035
	Next Generation AI Development Plan (China's State Council, 2017).
<b>Gross national income per capita (2019)</b>	\$16 790 (Rank 82 out of 192 countries)
<b>Human Development Index (2019)</b>	0.761 (Rank 85 out of 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	8.1
<b>Inequality Index (2021)</b>	0.51
<b>Government AI Readiness Index 2021 (Oxford Insights, 2021)</b>	74.42 (Rank 15 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

### National

Smart education is classed as an education (system) provided by schools, regions or governments that includes a high-quality learning experience, learning content adaptation and teaching efficiency. Modern science and technologies are used to provide diversified supports and on-demand services for students, teachers and parents, etc., and the data about participants and learning and teaching processes are recorded and used to promote the quality and equity of education (Huang, 2014). Smart education is the high-end form of ICT in education (SLI-BNU, 2021 [in Chinese]), with technology infusing every aspect and process of education. China launched a Notice on the Recommendation and Selection of the Smart Education Pilot Zone Construction Project (MOE, 2019b [in Chinese]), and formulated the following six tasks for the development of smart education:

1. Develop mechanisms and approaches to promote both teachers' and students' digital literacy, awareness, computational thinking, digital learning and information social responsibility through relevant curricula and practices.
2. Introduce innovative teaching methods and strategies, such as hybrid education, learning and assessment to support the integration of ICT into education.
3. Use AI and big data to precisely assess students' quality of learning outcomes.
4. Offer personalized and on-demand services for teachers and students based on data interoperability provided by government and industry.
5. Develop mechanisms for collaborative innovation to promote the supply of open educational resources across regions for equal and inclusive education.
6. Use AI and big data to deliver these changes.



**Figure 3. China's smart education pilot**

## Regional

### *Minhang District, Shanghai City*

The government of Minhang District formulated and implemented the Plan of Creating a National Smart Education Pilot Zone in Minhang District, which promoted the comprehensive and individual development of teachers and students and the equitable and high-quality development of education. Measures include (People's Government of Yihang District [PGYD], 2021 [in Chinese]):

- Focus on achieving data-driven, large-scale and individualized teaching, while adhering to moral, intellectual, physical, aesthetics and work standards.
- Set up an educational cloud service platform that meets the needs of the region.
- Build a smart learning environment that supports personalized teaching and learning.
- Explore personalized and differentiated teaching and learning options.
- Explore the regional ICT public service system of collaborative innovation in production, learning and research.

### *Yuncheng City, Shanxi Province*

During the COVID-19 pandemic, Yuncheng City ensured that more than 800,000 teachers and students had access to synchronous online learning, including access to a network, a learning platform, learning resources and a learning account so that all students could learn anytime and anywhere (MOE, 2019a [in Chinese]).

### Qingdao City, Shandong Province

Qingdao City promoted students' information literacy in a variety of ways, including:

- strengthening their knowledge, skills, application ability and information awareness, information ethics, etc.;
- enriching the content of AI and programming courses;
- promoting the implementation of information technology curricula and integrating information technology into primary and secondary school curricula; and
- organizing multiple IT application exchange, promotion and competition activities (Qingdao Municipal Education Bureau [QMEB], 2020 [in Chinese]).

## Arab Republic of Egypt

The national smart education policy case study for Egypt is based on the country's adoption of a national AI strategy (NCAI, 2021) (hereafter referred to as the strategy) in 2021 in which education commitments and plans are firmly entrenched. Table 6 provides a brief demographic overview of Egypt.

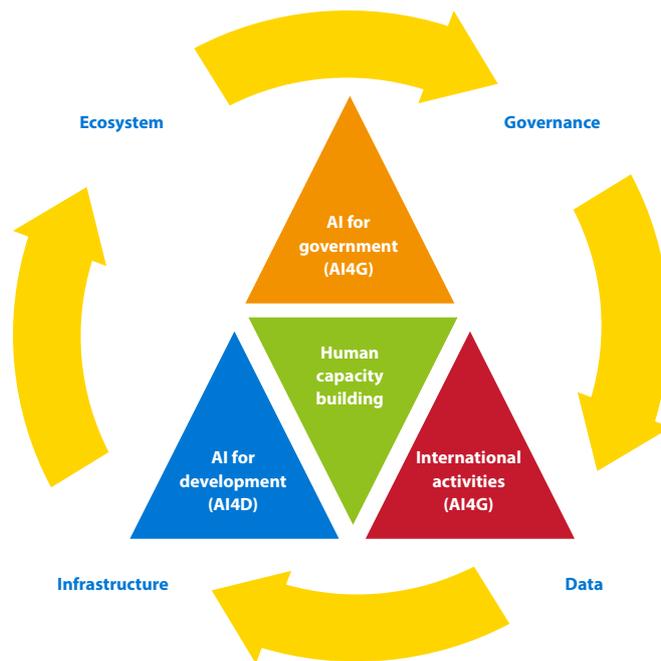
**Table 6. Basic demographic and education system information about Egypt**

<b>Population (August 2021)</b>	<b>104 549 307</b>
<b>Historical ICTE policies</b>	Egypt ICT Strategy 2007–2010
	Egypt ICT Strategy 2013–2017
<b>Smart education-related policies</b>	Egypt National AI Strategy (2021)
<b>Gross national income per capita (2019)</b>	\$11 840 (Rank 112 out of 192 countries)
<b>Human Development Index (2019)</b>	0.707 (Rank 116 out of 189 countries) - UNDP
<b>Mean years of schooling (2019)</b>	7.4
<b>Inequality Index (2021)</b>	0.47
<b>Government AI Readiness Index (2021)</b>	49.75 (Rank 65 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

## Smart education critical analytical framework attributes

Figure 4 provides a snapshot of the way the smart education critical analytical framework themes manifest in Egypt's national AI strategy.



**Figure 4. Smart education in Egypt's national AI strategy**

### Rationale for the AI strategy

The rationale for the strategy is informed by the Egyptian Government's view that AI promises a radical transformation of economic and social systems worldwide and that it is increasingly a policy priority for governments across the world.

The rationale for the adoption of the strategy is also to:

- use AI to build a modern state to achieve Egypt's development goals, and improve its citizens' quality of life;
- indigenize the AI industry and thus strengthen Egypt's leading role in both the region and throughout the world;
- communicate with stakeholders and learn from best practices on developing and using AI for the common good; and
- apply AI to areas such as education to help overcome staff shortages, improve access and reduce risks and costs.

The strategy also promotes Egypt as a regional hub for AI education and talent that can serve local, regional and international markets. In addition, it makes explicit reference to the adoption of a human-centric AI approach, which prioritizes people's well-being and facilitates multistakeholder discussion about responsible AI deployment for the benefit of society.

### Problem statement

The strategy identifies a host of labour market and economic challenges to which it needs to respond. For example:

- Much AI talent leaves Egypt once they have been trained.
- The private sector is resisting the adoption of AI, primarily because it requires large capital investments and the return on investment is uncertain.
- AI research is dominated by a few global AI superpowers and large technology companies, which challenges Egypt's ability to lead international AI research.

## AI strategy vision, mission and values

The strategy's vision and mission position Egypt as a leading regional player in Africa and the Arab region and in the world by mobilizing AI technologies to serve both developmental and global economic competitive goals. It aspires to expand its AI industry by encouraging skills development among its population for sustainability and competitiveness.

## Strategy model

The strategy model has four key pillars and four enablers, which resonates broadly with the smart education policy framework. The pillars are:

- **AI for Government (AI4G)**, which serves to increase the efficiency, quality and speed of government-to-citizen services and improve the performance of the entire government by using AI to improve the quality, efficiency and transparency of decision-making processes.
- **AI for Development (AI4D)**, which aims at using AI to address societal problems.
- **Capacity Building (AI4H)**, which focuses on the development of AI skills and competencies among citizens. This pillar proposes the development of lifelong learning and reskilling systems to contribute to workforce development and sustained employability and to prepare the Egyptian population for an AI age. Much of the smart education, AI in education and 4IR in education and training system is embedded in this pillar.
- **International Activities (AI4X)**, which focuses on fostering regional and global cooperation.

The enablers in the strategy model align with key themes in the Smart Education Policy Framework. They are:

- **Governance:** The strategy established a National Council on AI to implement and govern its AI strategy, including a dedicated focus on ethics in AI.
- **Data:** The inclusion of data as an enabler acknowledges the rapid growth in the volume of data and the need for a data strategy that defines the roles and responsibilities of each data actor in ways that build transparency.
- **Infrastructure:** Recognize the centrality of developing Egypt's AI infrastructure and make the link to its national digital strategy focused on infrastructural policies and strategies.
- **Ecosystem:** The plan is to establish an AI Centre of Excellence to engage with an emergent AI ecosystem in Egypt in designing AI solutions.

## Human capacity-building, skills and competencies (AI4H)

The strategy's capacity-building pillar identifies the need to:

- Raise public awareness of AI and its uses, benefits, risks and limitations so that Egypt has citizens who are educated, knowledgeable users of AI systems.
- Take the following steps in the formal education and training sector:
- Expose students to the basics of AI as part of their standard school education and to teach AI in a fun, interactive way.
- Grow the computing and AI talents of students in TVET institutions and develop TVET educators with the skills to teach AI-related subjects.

- Establish new, dedicated 'Faculties of AI' at universities and reposition existing computing and engineering faculties as AI faculties that integrate AI in their course offerings. This entails developing specialized postgraduate programmes in partnership with AI specialist institutions.
- Upskill professionals working in IT-related jobs with specialized skills in AI system development and train non-technical professionals as domain experts who can work in AI development teams.
- Develop AI business schools to establish special programmes to grow the requisite AI skills and capabilities of executive-level professionals and workers in start-ups, government and the private sector.

The capacity-building pillar also includes plans to prioritize AI research in the spheres of both basic and applied research. To this end, the strategy contains the following policy recommendations:

- Increase AI research funding through local and international funding agencies and track research accordingly.
- Establish new centres for AI research.
- Actively encourage PhD students who are studying abroad to return to Egyptian universities and recruit renowned Egyptian expatriate researchers to take up visiting positions at newly established centres for AI research in Egypt.
- Link universities and research centres in Egypt with corresponding specialized entities elsewhere in the world.

## Strategy implementation, monitoring and evaluation

The strategy adopts an Execute-Plan-Explore implementation framework in order to be responsive and adaptive to sudden changes that will undoubtedly arise over time. It proposes a phased implementation over several years and includes a stated operating model for the first phase of the plan, from 2020 to the end of 2022. The first phase identifies key initiatives in each of the four pillars and includes a model for its ongoing monitoring and evaluation.



### Possible gaps and tensions

The strategy includes a discussion of challenges, gaps and tensions. It tries to reconcile human development, human-centric goals with a global competitiveness agenda. It highlights concerns about the ethics of AI systems; the potential of AI to cause harm to individuals, communities and systems; and issues such as bias, gender equality, insufficient regulation and the loss of nuances in culture and language.

The strategy also acknowledges that its capacity-building agenda will be difficult to implement by highlighting the possibility of a national brain drain and the private sector's reluctance to invest in high-capital AI ventures.

## Republic of India

The Indian Government adopted its National Policy on ICT in School Education in 2012. In response to the global growth of AI, it then commissioned its think tank agency, the NITI Aayog, to develop a cross-sectoral national strategy for AI, which was finalized in 2018. The latter contains specified recommendations on education and skills development, which will be the focus of this case study.

The National Strategy for AI (hereafter referred to as the strategy) draws on previous reports produced by a dedicated AI task force whose role was to suggest ways to promote AI and to develop an AI policy framework for India (NITI Aayog, 2018). The task force established subcommittees to work on specific areas. Following the submission of their reports in July 2019, the NITI Aayog and the Ministry of IT have been working on a national AI programme and policy (NITI Aayog, 2018). Table 7 provides a brief snapshot of key demographic, economic and social indicators for India.

**Table 7. Basic demographic and education system information about India**

<b>Population (August 2021)</b>	<b>1 395 012 869</b>
<b>Historical ICTE policies</b>	National Policy on Information and Communication Technology (ICT) in School Education (2012)
<b>Smart education-related policies</b>	National Education Policy 2020 National Strategy for AI (2019)
<b>Gross national income per capita (2019)</b>	\$6 920 (Rank 134 out 192 countries)
<b>Human Development Index (2019)</b>	0.645 (Rank 131 out 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	6.5
<b>Inequality Index (2021)</b>	0.479
<b>Government AI Readiness Index (2021)</b>	74.42 (Rank 15 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

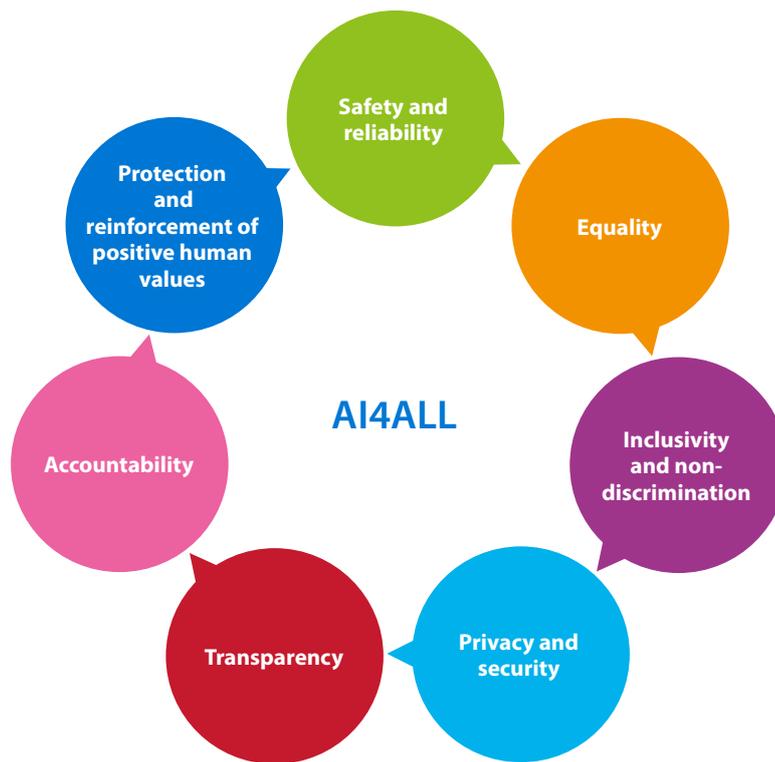
Figure 5 provides a snapshot of the way the smart education critical analytical framework themes manifest in India's national AI strategy discussion paper.

### Rationale and approach

The NITI's approach to developing a national AI strategy was to consider ways in which India can leverage AI not only for economic growth but also for social inclusion. Its report refers directly to the inequalities that AI investment can cause.

### Guiding principles: #AIforAll

Consistent with the rationale to combine economic competitiveness with social inclusion imperatives, the guiding principles of the strategy are informed by the need to leverage AI to ensure social and inclusive growth in line with the government's development philosophy. The theme of the AI strategy is '#AIforAll: Technology Leadership for Inclusive Growth' and it is guided by its stated interest to optimize social benefits rather than maximize top-line growth.



**Figure 5. Smart education in India's national AI strategy**

The NITI's report was published in 2021 and lists seven principles that align with the stated aim to take a responsible approach to AI:

- Safety and reliability
- Equality
- Inclusivity and non-discrimination
- Privacy and security
- Transparency
- Accountability
- Protection and reinforcement of positive human values

### Problem statement

The problems that the AI strategy needs to respond to are expressed as barriers:

- The lack of broad-based expertise in research into and the application of AI.
- The absence of enabling data ecosystems.
- The high costs of and low levels of awareness about the adoption of AI.
- The threats to privacy and security.
- The absence of a collaborative approach to the adoption and application of AI.

## Strategic goals

The strategy states goals that relate to both economic and social development imperatives. They include:

- Leverage AI for economic growth by capitalizing on intelligent automation, the enhancement of labour and capital and the diffusion of innovation.
- Leverage AI for social development and inclusive growth. It has the potential to transform society and improve the quality of life of many of India's citizens.
- Develop India as an AI hub. This means that India could serve as the world's innovation playground where enterprises from across the world can explore innovations that can be scaled and then exported. India aims to be the AI hub for 40% of the world.

Within the parameters of these goals, the strategy focuses on five sectors that are expected to benefit from AI: health care, agriculture, education, smart cities and infrastructure, and smart mobility and transportation. This case study discusses the education focus, which is premised on the view that AI can improve access to and the quality of education for India's population.

## Skills and competencies

The strategy references India's recently adopted New Education Policy (NEP) 2020 and the way it prioritizes computer programming and coding to be part of the curriculum from Class 6 onwards (MHRD, 2020). It also highlights the development of AI courseware and modules for schools, some of which have already been developed through various partnerships. For instance, the NITI Aayog Atal Innovation Mission developed an AI module for school students in partnership with MEITY and NASSCOM, and MEITY and Intel India have designed a national programme for government schools called Responsible AI for Youth.

The strategy identifies the need to treat the reskilling and training of its workforce as a priority through incentives, tax breaks and grants for employers. The skilling and reskilling would equip workers to move on from jobs that may be under threat due to AI investments and prepare them for new jobs in emerging sectors. This type of skills training should begin at the school level so that India continues to build a workforce that can meet the needs of the twenty-first century.

## Research

The strategy includes an ambitious AI research agenda:

- **Promote AI research and applications:** This involves the establishment of Centres of Research Excellence (CORE) for AI and International Centres for Transformational AI (ICTAI), which will include PhD scholarships, faculty fellowships and inter-academia collaboration.
- **Establish a common data computing platform:** This would be a national-level AI research analytics and knowledge assimilation platform (AIRAWAT) for big data analytics with large AI computing infrastructure connecting all COREs, ICTAIs and academic institutions within a national knowledge network.
- **Create a 'CERN for AI':** The Indian government should take a lead in establishing a supranational institutional architecture that functions as a 'People's AI: CERN for AI' and involves collaboration with other interested national governments.

Linked to the research agenda are two dedication flagship initiatives which also focus on research:

- Centres of Research Excellence in AI (COREs) will focus on fundamental research and act as technology feeders for International Centres for Transformational AI (ICTAIs), which will focus on creating AI-based applications in domains of societal importance. A consortium of ethics councils to oversee activities at each CORE is also proposed.
- An AI hub (commonly referred to as an AI garage) to give companies an opportunity to explore their AI innovations in India and distribute them across the world from India.



### Potential tensions and gaps

The strategy reflects an awareness of the balance that the Indian Government is trying to strike between the risks of investment in AI and the opportunities that AI presents for India's population. It notes the need for the government to lead the AI strategy so that the inclusive, societal benefits are prioritized in ways that do not crowd out the private sector. Managing these tensions will require investment in expertise and in systems and processes to facilitate effective management and accountability structures and safeguard the responsible AI approach that the strategy also promotes.

The strategy provides a high-level macro-overview of the intentions and plans of the Indian Government with reference to AI. Much of the complexities will likely arise when the flagship initiatives and plans are implemented. This is where the strategy will be put to the test in terms of the way AI will be harnessed to benefit learning and teaching, skills development and the inclusive, equitable societal objectives that the strategy has set out.

## Republic of Mauritius

The national smart education policy case study for Mauritius draws on a report titled *Mauritius Artificial Intelligence Strategy*, published by the government-established Working Group on Artificial Intelligence (WGAI, 2018). The case study draws on the aspects of the strategy report that relate to the education and training system in Mauritius. Below is a brief demographic overview of Mauritius.

Figure 6 provides a snapshot of the way the smart education critical analytical framework themes manifest in Mauritius's national AI strategy discussion paper.

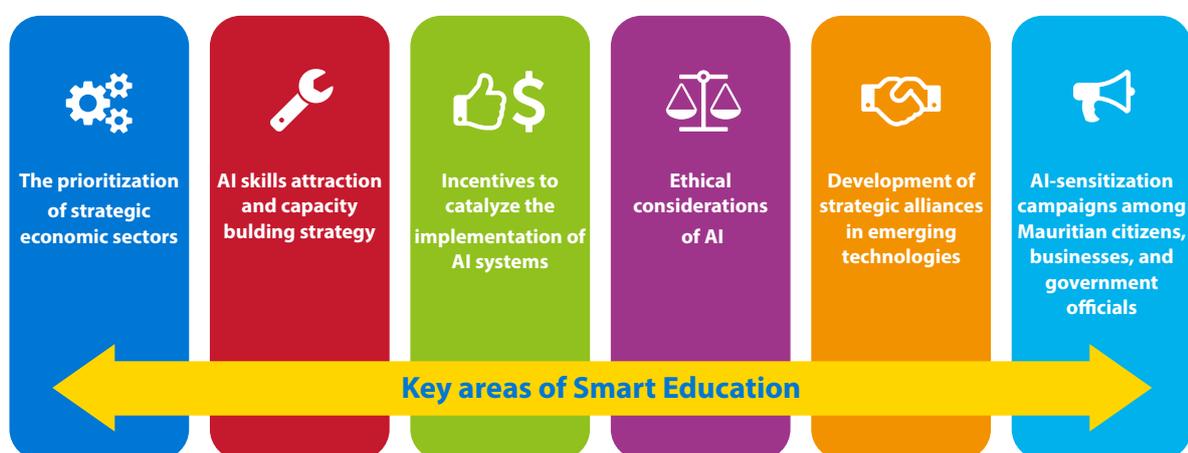


Figure 6. Smart education in Mauritius's national AI strategy

**Table 8. Basic demographic and education system information about Mauritius**

<b>Population (January 2022)</b>	<b>1 275 128</b>
<b>Historical ICTE policies</b>	National ICT Strategic Plan 2011–2014: Towards i-Mauritius
	National ICT Policy 2007-11
	ICT Education in Mauritius
	National Open-Source Software Strategy for the Republic of Mauritius 2014
	Policy of The Republic Of Mauritius with Respect to the Telecommunications Sector
<b>Smart education-related policies</b>	Digital Mauritius 2030 Strategic Plan
	Digital Government Transformation Strategy 2018–2022
	Mauritius Artificial Intelligence Strategy 2018
	ICT Strategy for the Mauritius's Education Sector presented by Education Minister
	COVID 19, technology-Based Education and Disability: The Case of Mauritius
	National Open Data Policy 2017
<b>Gross national income per capita (2019)</b>	\$26 790 (Rank 59 out 192 countries)
<b>Human Development Index (2019)</b>	0.804 (Rank 66 out 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	9.5
<b>Government AI Readiness Index (2021)</b>	52.71 (Rank 58 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

## Rationale

The strategy report locates the rationale for an AI strategy for Mauritius within a global context: more than forty countries had adopted AI policies and strategies by 2018, based on different aspects of AI policy such as research and development, capacity-building and skill development, education, ethics and inclusion. By then, AI was already growing rapidly and its influence had permeated many economies, industries and social systems. PricewaterhouseCoopers (2017) estimated that it would be contributing US\$15.7 trillion to the global economy by 2030.

The rationale for an AI strategy is further informed by a shared view that the affordances and capabilities of AI contribute to economic, social and financial gains; that AI can be a vector in the revival of traditional sectors in the economy; and that AI systems can create new opportunities for the development of Mauritius.

## Problem statement

The strategy report highlights three interrelated challenges, which the AI strategy will need to address: the AI skills crisis, cybersecurity and data privacy concerns, and ethical and moral challenges.

The AI skills crisis is defined in human capital terms as a growing labour market demand for more advanced, specialized skills in the workplace. The strategy report also identifies a capability gap in the recruitment of people with the required skills and talents in areas such as data science, cybersecurity and computer science, or with advanced STEM skills. The skills gap can be traced in part to academic and training institutions not being able to keep pace with innovation and changes to build the requisite skills in their students. Moreover, private companies are yet to define their AI strategies and were not investing in the requisite AI training programmes to develop their AI capacity. There is concern that the skills crisis, combined with increasing automation and capital intensity, will lead to job losses if it not addressed. Employees must be appropriately reskilled and upskilled to fill jobs in newly emerging AI-intensive sectors.

The cybersecurity and data concerns relate to the threats that AI applications face from cybersecurity attacks via hackers or the ways that AIs have learned from analysing data and making decisions independently of human interaction. The latter increases the power of AI especially when larger volumes of data are involved. When this is combined with poor data governance, the risks to privacy and data protection are exacerbated.

The ethical and moral challenges raised in the strategy report are discussed from the perspective of AI systems not being able to make fair and moral decisions because ethical and moral issues are difficult to integrate into the training of AI systems. The risk of amplifying and reproducing structural discrimination is intensified particularly in the absence of an explicit code of ethics and appropriate AI governance.

## Vision

The strategy's vision is for Mauritius to be a highly interconnected society with access to the knowledge required for an innovation-driven culture.

## Strategy recommendations on smart education-related skills and competencies

The strategy report proposes a host of areas in which the government could intervene to enable an AI-capable economy and society. For example:

- The prioritization of strategic economic sectors and identification of related national projects for investment by the Mauritian Government. The strategy specifies the manufacturing, energy and transport, ocean economy and fintech sectors.
- A skills attraction and capacity-building strategy.
- Incentives to encourage the implementation of AI systems.
- Ethical considerations of AI.
- The development of strategic alliances in emerging technologies.
- AI-sensitization campaigns directed at Mauritian citizens, businesses and government officials.
- The adoption of new technologies for improved public services delivery.

For the purposes of this current report, the overview focuses on the skills development, skills attraction and capacity-building aspects of the strategy report, which also aligns with the skills and competencies themes in the framework.

The strategy report makes a host of recommendations that can contribute to the development of an AI-capable labour market and economy. The focus of change is the education and training system, particularly the schools, universities and related education and training institutions. The recommendations include:

- Incentivizing and attracting AI talent and capabilities by identifying and importing talent from abroad. The report identifies skills and expertise in AI research, the design of applications and the use and adoption of AI systems in business as those that are most needed by the Mauritian economy and labour market. In the short term, it is recommended that expertise be imported via the Mauritian Diaspora Scheme and Innovators Occupation Permit, which were established to attract foreign expertise and specialists.
- Encouraging the training of computer scientists and mathematicians in the medium term and establishing an AI campus for this purpose in partnership with local universities and international experts. The AI campus would target specified numbers of students and deliver tailor-made programmes over short periods so that the students can be deployed to the relevant economic sectors.
- Reviewing existing elective modules at universities and making computer programming and coding mandatory for all subjects. This recommendation is also linked to making available scholarships for advanced training in AI to locals and to foreign students in Mauritius.
- Promoting science, technology and mathematical literacy, and increasing digital science and AI training in high schools and universities. The pipeline of graduate students in AI-related fields should be built through the democratization of science and the promotion of careers in the mathematical sciences from the primary school level.
- Investing in STEM education, national retraining programmes and lifelong learning with collaboration between education institutions, and establishing a 'talent watch' to determine industry's AI skills needs with a view to matching training to employment and hence stronger dialogue and linkages between industry and education institutions.
- Establishing a more efficient qualification authority approval process so that universities can adapt and upgrade their training and course offerings to meet the growing need for a skilled AI labour force, and encourage inter-university collaboration so students can access the programmes and expertise across universities.
- Creating a scheme to facilitate occupational mobility by reskilling workers who have lost their jobs for AI-related reasons.

## Governance

A key recommendation related to the governance of AI systems and their integration into the education, training and priority economic sectors is the need for the Mauritian Government to develop an appropriate legal and regulatory framework. Here the strategy report highlights the importance of building public trust by protecting the privacy and safety of citizens' data. The report acknowledges that the existing legal frameworks may be limited in this respect and may also constrain the expansion of an R&D and innovation culture in Mauritius. It therefore proposes that the country's intellectual property rights laws be revisited; that the data protection legislation be addressed by a special working group; and that a new IP bill be expedited. Furthermore, it recommends that, where AI solutions are developed with private developers, the solutions should remain the intellectual property of the private developers, even if the developers received government support. At the same time, it also recommends that the legal framework should ensure that human decision-making can override artificially intelligent decision-making.

## Leadership, system strengthening and change management

The strategy report recommends that a Mauritius Artificial Intelligence Council (MAIC) be established to spearhead and drive the AI strategy. Its responsibilities would include coordinating, implementing and monitoring innovative projects in partnership with relevant stakeholders.



### Possible gaps and tensions

The strategy report is mindful of the complexities associated with developing and implementing an AI strategy for the Mauritian Government both in general and in the specific context of its education and training system. It makes a list of salient recommendations that align with similar strategies in various other countries. The recommendations suggest that further policies, laws and regulations need to be developed and that relevant systems need to be established to implement the proposed recommendations. The education and training space has many gaps that will need to be addressed, including strategies to ensure that the tensions between developmental, humane and ethical design and globally competitive, algorithm-centred technological change are appropriately managed. It will therefore be important to pay more attention to growing responsible AI leadership and capabilities in decision-making structures and advisory councils, as recommended by UNESCO and UNICEF in their frameworks on AI and education and AI and children, respectively.

The strategy report highlights concerns about the ethics of AI systems; the potential of AI to cause harm to individuals, communities and systems; and issues such as bias, gender equality, insufficient regulation and the loss of nuances in culture and language. In addition, it acknowledges that implementing its capacity-building agenda will be difficult because of a potential brain drain and the private sector's reluctance to invest in the high-capital AI initiatives.

## Russian Federation

Currently there is no single holistic concept of smart education accepted at the federal level in Russia. However, a range of projects and policies dedicated to key aspects of a smart educational system have been launched recently. A brief demographic overview of Russia is provided in Table 9. Below is a detailed analysis of each project.

**Table 9. Basic demographic and education system information about Russia**

<b>Population (August 2021) *</b>	<b>146 003 798</b>
<b>Historical ICTE policies</b>	Strategy of Development of Education in the Russian Federation for the Period Until 2025 (2015)
<b>Smart education-related policies</b>	
<b>Gross national income per capita (2019)</b>	\$28 260 (Rank 55 out 192 countries)
<b>Human Development Index (2019)</b>	0.824 (Rank 52 out 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	12.2
<b>Inequality Index (2021)</b>	0.439 (Rank 24 out of 106 countries)
<b>Government AI Readiness Index (2021)</b>	61.93 (Rank 38 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

## Monitoring the transition towards smart education

As a part of monitoring the achievements of the Digital Transformation National Goal, the Ministry of Education and Ministry of Digital Development, Communications and Mass Media collected data to assess the digital maturity of general education. The level of digital maturity was calculated according to five indicators:

- The percentage of students for whom a digital profile is maintained.
- The percentage of students who were advised on how to improve the quality of their education and the formation of individual trajectories based on student digital portfolio data.
- The share of teachers who had an opportunity to use verified digital educational content and digital educational services.
- The proportion of students who had free access to qualified digital educational content and services for self-study.
- The proportion of tasks or assessments in electronic form that were checked using automated verification technologies.

These indicators are focused mainly on the availability of the technical infrastructure of smart education.

## School team orientation: Training programme in digital transformation

In order to introduce a digital educational environment to schools, a training programme for school teams in the field of digital transformation was launched in 2020 by the Center for Project and Digital Development of Education (part of the Russian Presidential Academy of National Economy and Public Administration [RANEPA]). More than 17,000 participants completed the programme. It is envisaged that the school digital transformation team will include school principals and deputies, two to three teachers, school board representatives and parents. Representatives from educational authorities and universities were also invited. Seventy per cent of the training programme is practice-oriented, with school teams working on school transformation strategies.

## Standards for smart learning environment components

Several standards were recently introduced by the Federal Agency for Technical Regulation and Metrology (the Russian Federation's national standards body) in the field of smart learning environment components and technologies:

- GOST R 59899-2021: 'Educational products with artificial intelligence algorithms for adaptive learning in general education. Technical requirements.'
- GOST R 59897-2021: 'Data for artificial intelligence systems in education. Requirements for the collection, storage, processing, transfer, and protection of data.'
- GOST R 59896-2021: 'Educational products with artificial intelligence algorithms for adaptive learning in general education. Requirements for teaching materials.'

These standards provide indicators that determine if products, services and systems in education intended to be used for smart education are in line with smart learning environment technical requirements.

## The Digital Educational Environment federal project

The Digital Educational Environment (DEE) federal project launched in Russia in 2019 and is aimed at creating a safe digital educational environment in general educational organizations by 2024. The key objectives of the project, to be achieved by 2024, include:

- developing and implementing a professional training programme on the introduction and functioning of the target model for a digital educational environment in schools for school principals and executive authorities in education;
- introducing relevant digital technologies in educational programmes in 25% of schools throughout the country;
- providing 100% of schools with an internet connection speed of at least 100 Mb/s in cities and 50 Mb/s in rural areas;
- building a network of digital education centres; and
- implementing the target model of a digital educational environment throughout Russia.

The management of the education system within its various contexts in an evolving digital environment requires a comprehensive understanding of a typical Russian school, based not only on conventional indicators, such as territorial affiliation, school size, etc., but also on process changes in the use of digital technologies in education.

### Monitoring the digital transformation of general education organizations

In recent years, two complex studies of schools' transition towards a digital environment have been conducted in Russia:

- The Monitoring of the Education Economy (MEE) in 2021, a recurring data-gathering exercise on the economic state of the Russian education system since 2002, which provides information about basic digital educational infrastructure accessibility in schools, and the strengths of the digital transformation of education. MEE is conducted by a higher education school of economics.
- The Monitoring of the Digital Transformation of General Education Organizations (MDT-GEO) in 2019–2022. The 2021 MDT-GEO project included schools from fourteen regions that participated in a 2020 experiment to implement the target model of the DEE project. An ethnographic study of these schools within the framework of the monitoring revealed that the DEE experimental regions rated higher on the index that measured the use of basic digital technologies by students in classroom activities. The other indicators, however, showed no significant differences between the schools that participated in the DEE federal project and schools that did not. The MDT-GEO collected both quantitative and qualitative data.

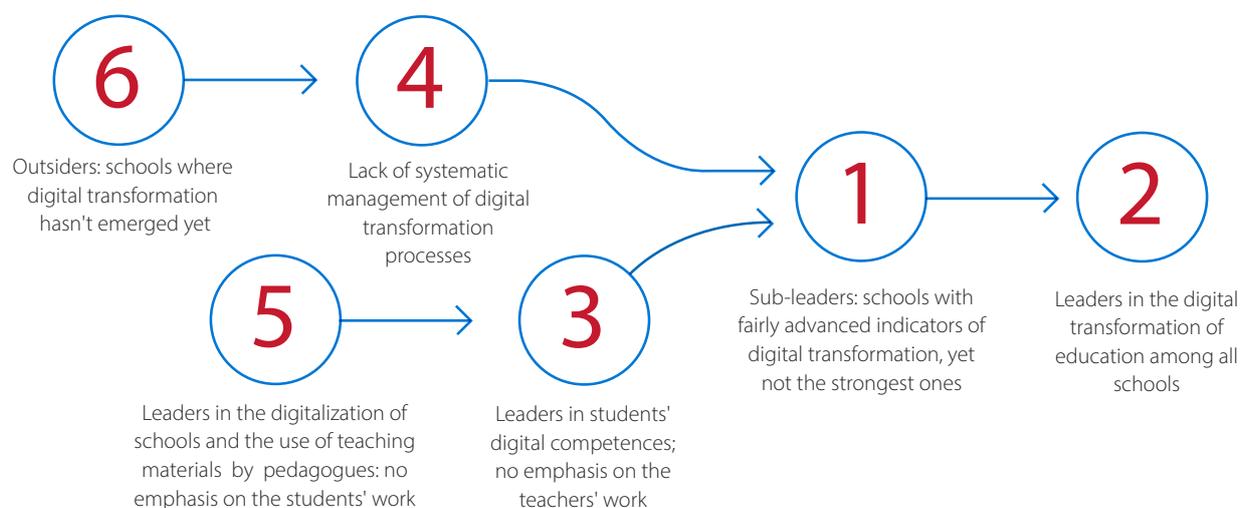
The overall experience of the monitoring of the MDT-GEO confirmed the advantages of combining different types of data (quantitative and qualitative) to create a more comprehensive picture of the state of digital transformation in Russian schools. The survey data – obtained from Russian regional and municipal education authorities, school managers, teachers and high school students from approximately 500 schools – were validated and broadened within field ethnography of schools.

In addition, the 2021 MDT-GEO findings illustrate that:

- personal digital gadgets (smartphones, tablets, etc.) are used by both students and school staff in the school environment (and educational space beyond) for both personal and educational purposes almost simultaneously, which gives rise to the problem of safe and effective use of technologies in schools;
- the gap between the digital competencies of students and teachers in Russian schools is growing – and not in the favour of teachers;

- there is a significant gap between high school students in urban and rural areas in terms of their attitudes to digital technologies and how they self-assess their digital competency; and
- strategic planning and elaboration of key objectives for the digital transformation of education management at the school level are often carried out without the involvement of all stakeholders; in particular, most of the teachers who participated in the study indicated that they were not involved in the development of a programme for the use of digital technologies in their teaching practice.

The framework of the MDT-GEO made it possible to identify various clusters of homogeneous Russian schools, common features within these groups and key differences between them. This in turn contributed to an understanding of the patterns in which schools transition from one identified group to another (see Figure 7).



**Figure 7. Transitions of the identified clusters of Russian general education schools towards smart education**

An understanding of these types of schools and their routes towards digital transformation and smart education enables the elaboration of first standard and subsequently personalized recommendations for the digitalization of Russian schools within the constraints of limited financial and technological resources.

Overall, the results of the MDT-GEO demonstrate that evaluating the transformation processes of educational organizations in an evolving digital environment allows for strategic planning of the available resources so that each school's measures of development and support are relevant to their needs and options. In particular, it was established that the work on differentiating digital transformation support measures for schools in Russia can be employed at the regional level in the following ways:

- identifying schools that do not have the basic infrastructure or equipment required for the integration of digital technologies (computers and internet);
- developing standard digital transformation plans for schools;
- supporting in-school information management systems; and
- mapping the digital ecosystem of services and platforms for use in teaching and learning.

## Republic of Singapore

The national smart education policy case study for Singapore draws on the country's recent national AI strategy (hereafter referred to as the strategy) in which education commitments and plans are firmly entrenched (Smart Nation Singapore [SNS], 2019). Table 10 provides a brief demographic overview of Singapore.

**Table 10. Basic demographic and education system information about Singapore.**

<b>Population (August 2021)</b>	<b>5 901 258</b>
<b>Historical ICTE policies</b>	ICT Masterplan I (1997–2002)
	ICT Masterplan II (2003–2008)
	ICT Masterplan III (2009–2014)
	ICT Masterplan IV (2015–2020)
<b>Smart education-related policies</b>	Smart Nation Strategy (2018)
	AI Singapore
<b>Gross national income per capita (2019)</b>	\$92 270 (Rank 2 out 192 countries)
<b>Human Development Index (2019)</b>	0.938 (Rank 11 out 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	11.6
<b>Inequality Index (2021)</b>	0.398
<b>Government AI Readiness Index (2021)</b>	82.46 (Rank 2 out of 160 countries)

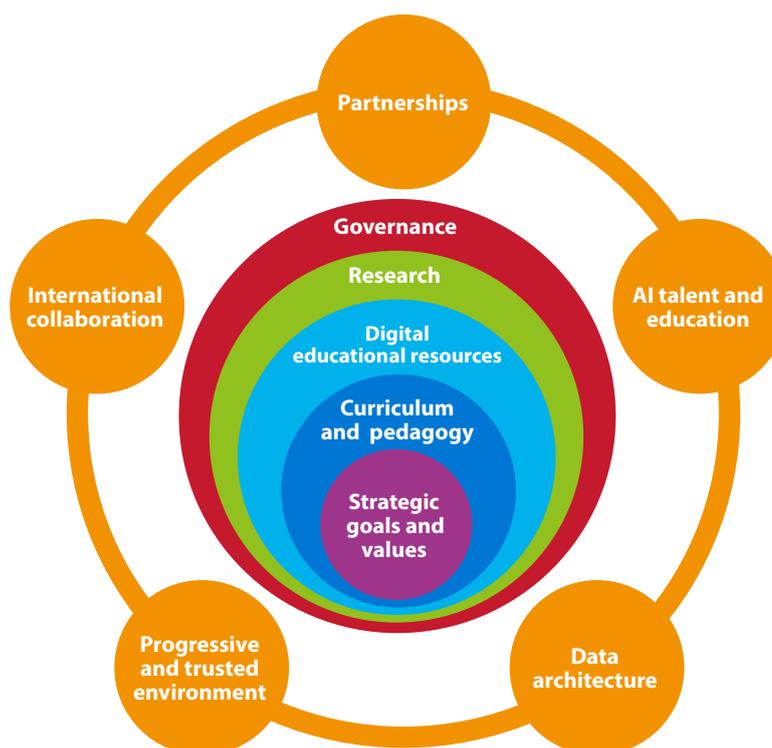
Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

### Policy influences and context

The factors that influence Singapore's adoption of a smart nation strategy stem from the country's political history of control and domination under British and Malaysian rule. Since independence in 1965, Singapore has embarked on a concerted strategy that has systematically developed its national system of innovation and positioned itself as a leading, learning, smart nation within a globally competitive economic and labour market. The country has a reputation for ranking among the top performers in international standardized assessments such as the OECD's Programme for International Student Assessment (PISA), a triennial test for fifteen-year-olds in dozens of countries in mathematics, reading and science. Singapore has adopted successive five-year macro-level ICTE masterplans since 1997. The design and implementation of these plans at national and classroom levels have been extensively analysed and evaluated (Koh and Lee, 2008; Looi et al., 2021).

Singapore adopted a large-scale effort towards digital transformation, the Smart Nation Initiative, in 2014. The country is a top performer in a smart city index of 109 cities across the world and it chairs the ASEAN Smart Cities Network (ASEAN, 2019). In 2019, it adopted a national AI strategy as an extension of its Smart Nation Initiative.

Figure 8 provides a snapshot of how the smart education critical analytical framework themes manifest in Singapore's national AI strategy discussion paper.



**Figure 8. Smart education in Singapore's national AI strategy**

### Rationale

The rationale for Singapore's national AI strategy is informed by globally competitive economic priorities, including the shifting geopolitical landscape both globally and in the ASEAN region which has been underscored by the influence of rapid technological growth and diffusion. The Singaporean Government adopted the AI strategy as an imperative to survive and thrive in a globally competitive environment by building the country's technological capabilities. The rationale is also motivated by an urgent drive for economic transformation, including the redesign of business models and new growth areas to improve productivity gains.

### Problem statement in education

The specified education challenge that the strategy highlights is the differential learning needs, aptitudes strengths and interests of students and the limitations teachers face in personalizing the learning experience for their students. Teachers are also limited in how much continuous and detailed feedback they can provide for students, and their routine tasks are time-consuming. The framing of these challenges illustrates the need to leverage the datafied, predictive affordances of AI technology systems in education, particularly those that can assist with personalized learning and foster efficiency gains.

### AI strategy vision, mission and values

The national AI strategy is regarded as a living document that is intended to lead to Singapore being at the forefront in the development and deployment of scalable, impactful AI solutions in sectors of high value and relevance to its citizens and businesses by 2030.

The aspiration is for Singapore to:

- be global hub for developing, test-bedding, deploying and scaling AI solutions;
- learn how to govern and manage the impact of AI;

- enable government and businesses to use AI to generate economic gains and improve lives – AI systems will therefore be leveraged to raise the government’s capacity to deliver anticipatory and personalized services and be a strong driver of growth in key sectors of Singapore’s economy; and
- ensure that Singaporeans understand AI technologies and its benefits and that Singapore’s workforce is equipped with the necessary competencies to participate in the AI economy.

## Strategy goals and values

The strategy goals are values-based in that they are geared towards:

- promoting a human-centric AI approach whereby people’s well-being is prioritized, and
- facilitating multistakeholder dialogues that can inform policy development on the deployment of responsible AI for the benefit of society.

## Infrastructure

The strategy promotes access to supercomputing infrastructure as a driver of fundamental AI research. Over the five-year time frame of the strategy, the Singapore Government is committed to investing S\$200 million to upgrade the country’s supercomputing capability and network speed and quality. This will raise supercomputing resources from 1 petaflop to 15–20 petaflops to support high-end compute performance needs. In terms of AI, the enhanced supercomputing platform will support the development and training of new AI algorithms and models.

## Curriculum and pedagogy and digital education resources and platforms

One of the five national AI projects focuses on personalized education and adaptive learning and assessment. The five projects are applied in specific subjects to explore ways in which teachers can better customize and improve the learning experience for every student. The education objectives are focused on:

- Leveraging AI through the recently launched Singapore Student Learning Space (SLS), an online learning platform for students and teachers in the national school system, to enable more personalized learning and assessment for every student.
- Enhancing the AI-enabled adaptive learning system embedded within the SLS. The adaptive learning system will use machine learning to enable it to assess individual student responses to learning materials and activities and guide the student on personalized responses, thereby enabling personalized learning pathways for each learner, customized to their individual learning needs.
- Improving the efficiency of the assessment of students’ work with an AI-enabled automated marking system that can assess open-ended student responses and provide timely feedback, thereby embedding assessment in the learning process.
- Taking a holistic approach to student development through an AI learning companion that could motivate students, keep them engaged during challenging tasks, help them reflect on their learning experience and recommend further learning activities.

## Perceived benefits

The strategy suggests that automating learning and assessment could allow for more a personalized learning experience, tailored to the individual strengths and weaknesses of each student. Teachers could use their time more efficiently as they move away from routine assessment tasks and focus more on data-driven student learning, and students with diverse learning needs will likely be more supported which in turn raises the potential of improved student performance.

In view of the potential perceived benefits as mapped out in the strategy, Singapore had already begun the pilot of an AI-enabled automated marking system for English language classes with selected primary and secondary schools in 2020 and was planning to test the adaptive learning system through the SLS for specific mathematics topics in upper-primary and lower-secondary levels in selected schools in 2022.

## AI talent and education

Multidisciplinary talent is both the foundation and the bottleneck in the realization of Singapore's AI vision. Multidisciplinary talent as defined by the strategy includes talent and skills in AI, digital and business domains so that AI solutions can be deployed to key sectors.

For Singapore, the key needs are:

- AI researchers and scientists with relevant industry R&D experience;
- data engineers and technicians with experience in using data to continually develop and improve AI solutions;
- AI engineers/translators/developers who can design and build user-centric products to drive large-scale adoption; and
- application developers, infrastructure engineers/developers and systems integrators with experience in building and operating large-scale machine learning systems.

The country will be establishing systems to track the supply and demand of AI talent and human capacity, which will also serve to guide its AI capacity-development, training and talent initiatives.

The AI talent and education ecosystem enablers will focus on:

- Training more Singaporeans for high-quality AI jobs by establishing more local talent pipelines to increase the quantity and quality of its AI workforce in the longer-term. Strategies to this end include:
  - creating AI conversion programmes and corporate-backed AI academies to upskill the latent pool of STEM and digital workers into higher-value AI-related job roles;
  - providing full-time postgraduate students, particularly AI PhDs with industry-relevant training in preparation for R&D roles in industry;
  - establishing the AI Apprenticeship Programme (AIAP) as a full-time nine-month programme by AI Singapore to turn out AI engineers for industry; and
  - helping Singaporeans understand the fundamentals and applications of AI in their workplace or daily lives.
- Teaching basic computing skills and computational thinking to all. This involves integrating and layering computer science across the learning journeys of all students, with the aim of developing 'bilingual individuals' who can apply computer science and AI concepts in their respective domains. Students will be encouraged to learn basic foundational concepts to spark their interest in AI at an early age, develop basic AI competencies and literacy, and have further opportunities to deep-dive into AI applications during higher education.
- Developing AI-ready graduates by encouraging institutes of higher learning to introduce domain-specific AI courses so that undergraduates understand how to apply AI to their areas of expertise and are able to leverage AI tools in their work.
- Training 25,000 professionals in basic AI coding and implementation by 2025.
- Scaling AI literacy courses to 100,000 adult Singaporeans and school-going children by 2025.

- Attracting top-tier global AI talent from around the world and developing local capabilities by mentoring emerging AI researchers and engineers and growing global talent networks.

## Governance

An appropriate and responsible AI governance and regulatory regime is pivotal to the strategy as it tries balance technology and business innovation with safeguarding citizens' interests. In this regard, the strategy involves:

- Establishing citizens' trust on the responsible use of AI. Singapore has established an industry-led Advisory Council on the Ethical Use of AI and Data. The council advises the government on issues arising from the commercial deployment of AI that may require policy or regulatory attention, and industry on the responsible development and deployment of AI. By 2019, it had developed its first Model AI Governance Framework. This framework provides detailed and readily implementable guidance to private sector organizations to address key ethical and governance issues when deploying AI solutions. In addition, Singapore will also:
  - develop sector-specific AI governance frameworks, including codes of practice and professional codes of conduct for different sectors and application contexts;
  - curate technical solutions that enable explainable AI that industry can use to augment their AI models;
  - develop training and certification in AI ethics and governance for professionals managing AI solutions and implementing AI projects, which will be overseen by the Singapore Computer Society's newly formed AI Ethics and Governance Steering Committee; and
  - publish assessment guides for organizations to assess the alignment of their AI governance processes with the Model AI Governance Framework.
- Applying multidisciplinary and human-centred approaches to study the systemic risks and long-term impact of AI, and developing potential solutions to address them.
- Providing a top-class IP regime and accelerated patent initiatives for AI. This means AI companies seeking to grow and expand internationally will need to develop a clear intangible asset (IA) and intellectual property (IP) strategy. To support companies, the Intellectual Property Office of Singapore (IPOS) has launched a new enterprise engagement arm, IPOS International, to provide them with customized IA solutions and programmes.

## Research

The strategy proposes the establishment of a triple helix partnership to lead a systematic AI research agenda, led by the research community, government and industry. It involves expanding AI-related R&D across the research ecosystem.

## Strategy implementation: Ecosystem enablers

The strategy anticipates that national AI projects, including the Personalised Education Project, will generate momentum for AI deployment and demonstrate the value of AI. To enjoy sustained benefits from AI, the Singaporean government will strengthen ecosystem enablers that drive AI innovation and adoption across the economy. These enablers include:

- triple helix partnerships,
- AI talent and education,
- data architecture,
- progressive and trusted environment, and
- international collaboration

While these ecosystem enablers are strongly interrelated, the focus of this document is on the AI talent and education ecosystem enabler.

## Partnerships

The strategy includes the establishment of strategic partnerships in ways that align with and propel the overall strategy – for example, the establishment of a partnership between government, industry and the research community known as a triple helix partnership, and the establishment of data-sharing partnership frameworks to encourage organizations to share and use data more pervasively for legitimate uses and help anchor public-private data collaboration and innovation.



### Possible gaps and tensions

While much progress has been made in policy and strategy development in AI and as a SMART Nation, the implementation of these at the macro, meso and micro levels will likely create complex, unforeseen tensions. As a statement of strategic intent, the strategy will need to be tested across the education, training and research ecosystem. The framing of AI systems in education and learning focuses on the data-intensive and predictive affordances of AI technology systems and less on the particularities and contexts of the students and teachers and the ways in which these influence their learning. Complex tensions are likely to also arise in the interrelationship between privacy, protection and datafication of learning and assessments and hence between the espoused vision towards becoming a global AI leader and the human-centric values of the strategy.

With reference to Singapore's lead role in the ASEAN via AI-integration, skills development, research and talent management will need to take account of asymmetrical relationships and divergent interests across the region and the need to manage and navigate these asymmetries.

## Republic of South Africa

In 2019, the South African Department of Higher Education and Training (DHET) minister established the Ministerial Task Team on the Fourth Industrial Revolution (MTT on 4IR) to advise him on the implications of the 4IR for the South African post-school education and training (PSET) system. The team's report (hereafter referred to as the report) was published in 2021.

Since ICTE policies in South Africa have already been analysed substantially (Isaacs, 2007, 2015, 2020) and the current focus is on emerging smart education policies and policy frameworks, the case study will focus on the findings and recommendations of the MTT on 4IR and its implications for policy and practice in the PSET sector in South Africa. The team's report on 4IR in PSET in South Africa is also the most recent policy-oriented text worthy of scrutiny. This current summary presents a case of emergent ideas that have smart education policy implications for a South African PSET context.

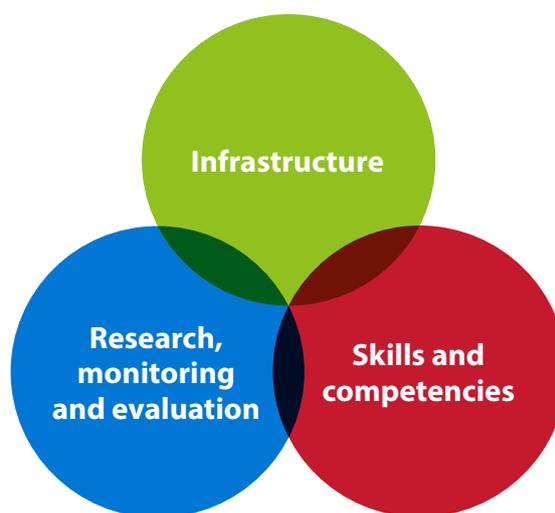
Table 11 provides a brief demographic and education system overview of South Africa as at 2021.

**Table 11. Basic demographic and education system information about South Africa**

<b>Population (August 2021)</b>	<b>60 135 403</b>
<b>Historical ICTE policies</b>	e-Education White Paper (2004)
<b>Smart education-related policies</b>	Ministerial Task Team on the Fourth Industrial Revolution and Post Schooling Education (2020)
<b>Gross national income per capita (2019)</b>	\$12 670 (Rank 108 out of 192 countries)
<b>Human Development Index (2019)</b>	0.709 (Rank 114 out of 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	10.2
<b>Inequality Index (2021)</b>	0.577
<b>Government AI Readiness Index (2021)</b>	48.24 (Rank 68 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

Figure 9 provides a snapshot of the way the smart education critical analytical framework themes manifest in the MTT's report on 4IR in the PSET system.



**Figure 9. Smart education in South Africa's MTT Report on 4IR in the PSET System**

The report defines 4IR as the current and developing environment in which the convergence of new digital, physical and biological technologies – for example, artificial intelligence, cloud computing, the Internet of Things, robotics, augmented reality, 3D printing and biotechnology – are merging with the physical lives of humans and changing the way humans interact, live and work. These trends and their unfolding social and economic effects have come to be known as the Fourth Industrial Revolution (4IR). The report also suggests that the 4IR differs from its predecessors because of its velocity, exponential rate, breadth, depth of convergence, and systems impact on industries, firms, governments and societies. It suggests that these shifts all underlie the change from labour-intensive production to knowledge and skills-intensive production for which countries will need a ready pool of digital, technical, commercial and management expertise. It also acknowledges that the 4IR can exacerbate or reduce inequality depending on government response.

In an attempt to learn from past ICTE policy experience, the report calls for a review of all PSET policies and legislation to streamline and simplify the PSET policy environment.

### Problem-responsive policy

The report adopts a human capital approach to framing the problems that policy on 4IR needs to address in the PSET sector: essentially, the country is not producing what is needed to maximize 4IR opportunities.

The report also identifies the following as critical systemic challenges that policy and strategy on 4IR in the PSET sector must address:

- The systemic crisis of youth unemployment.
- The limited effectiveness of significant investments in youth capacity-development.
- The binding constraints of the basic education sector.
- Growing poverty and social inequality.
- Policy implementation failures.

The report suggests that these factors have collectively contributed to limited throughput, learning and quality of preparation for entry into PSET by young people. It also highlights that South Africa faces unprecedented challenges as it engages with the complexities presented by the 4IR and suggests that these challenges cannot be addressed through slow, incremental change. Instead, South Africa will need to respond with purpose and speed. This requires a willingness to reconsider many of the core principles and operational models on which the PSET system is currently based.

### Vision, mission and values

The report aligns the vision of a PSET system integrated with 4IR technology systems with the national country vision as outlined in the South African Government's National Development Plan (NDP) 2030 and its values and principles. It suggests that 4IR technologies and tools be harnessed to create a better, more inclusive, wealthier South Africa that benefits all its citizens.

It also calls for a new social contract to leverage the opportunities of the 4IR to achieve the vision of the NDP. It proposes a new vision for the PSET system to provide:

- a strong core of education and training programmes that align with the changing needs of both South African society and the world of work in the context of the 4IR;
- access to high-quality educational opportunities that meet a burgeoning and immediate demand for 'digital skills' in the labour market created by the 4IR;
- a parallel need for a new wave of South African innovators and entrepreneurs who will help to drive and shape the 4IR to the social and economic benefit of all of the country's citizens;
- massive increases in short-course skilling opportunities for unemployed and underemployed South Africans in parallel with wider government and private sector efforts to rapidly grow new employment opportunities for those people; and
- more emphasis on integrating into PSET programmes and courses learning opportunities that prepare people to cope with accelerating change, both socially and economically, and thus emphasize key generic skills.

To realize this vision, the report proposes a host of measures, from adopting wider applications of new technologies to introducing work-integrated learning and developing integrated delivery models that work at different levels of the national PSET system.

## Strategy

The report proposes a three-track strategy for PSET systems reform:

- Growing and skilling the digital economy and enabling South African society to leverage the developmental benefits that can flow from the growth of the digital economy.
- Implementing supportive strategies that can drive large-scale employment growth for all South Africans.
- Ensuring the PSET system supports efforts to build an engaged and empowered citizenry who are better able to adapt to ongoing and uncertain technology-fuelled change.

The report presents practical steps in the short and long term and makes specific recommendations on key themes:

- That the affordances of the 4IR be integrated into the DHET's draft National Plan for PSET to develop an overarching PSET Reform Plan that recognizes the serious operational problems and proposes concrete strategies for an overhaul of the current PSET system. The draft plan is already under consideration by the minister, and the report sees this as an opportunity to integrate 4IR affordances into the final plan.
- That a review of all PSET policies and legislation be commissioned to enable clear identification of all the policy and legislative provisions that present impediments to the kind of systemic transformation envisaged in this report. The highest priority should be given to streamlining and simplifying the PSET policy environment in response to this review.

## Infrastructure

The report recommends that an integrated ICT plan be developed for the PSET system that includes providing affordable ICT devices and connectivity to all PSET students to ensure equitable access to learning opportunities made possible through the affordances of the 4IR. This should be an integrated section of the finalized national plan for PSET.

## Skills and competencies

The report recommends that the country's three quality councils (QCs), two departments of education and key non-profit and private sector actors be convened to plan a review and reform of credentialing and quality assurance processes in PSET to align them more effectively with the long-term needs of the PSET system and its students.

It also proposes that the DHET and its partners develop and implement flexible professional development programmes and make them widely available to institutions, educational staff, support staff and quality council staff to enable ongoing reskilling in preparation for the changes that will need to be made in the PSET system as the reform plan rolls out.

## Research monitoring and evaluation

The report proposes that the DHET and Department of Science and Innovation urgently convene a suitable mission board to integrate research and innovation into the PSET reform plan. The mission board should include science councils like the Council for Scientific and Industrial Research (CSIR) and Human Sciences Research Council (HSRC), relevant research chairs and key stakeholder groups – including students and PSET management, technology companies, international experts and partner departments.

Furthermore, the report recommends that small, cross-sectoral teams be established to begin planning and implementing new educational opportunities, to model the PSET change proposed, with one team focusing on skills development strategies, digital jobs and global business services and another on open-learning programmes and short courses in the TVET sector.



### Possible tensions and gaps

It is likely that tensions will arise from the focus of the problem statement being on addressing technology access and human capital challenges. The varying manifestations of inequality and exclusion and broader interrelated concerns such as privacy, data protection infringements, and security are critical issues to which the report pays less attention.

An added tension and gap relate to providing further clarity on the lessons learned to date on the constraints of policy implementation and how these challenges can be circumvented when addressing the report's recommendations.

## Republic of Korea

The government of South Korea adopted a national AI strategy in November 2020. South Korea has a long history of successive ICTE policies. The education commitments in the latest strategy are the focus of this case study. South Korea has one of the highest higher education completion rates of young people in OECD countries. It also has one of the world's highest smartphone penetration rates and has the world's best ICT infrastructure and semiconductor and manufacturing technology. Table 12 provides an overview of demographic and education information about South Korea.

**Table 12. Basic demographic and education system information about South Korea**

<b>Population (August 2021)</b>	<b>51 318 071</b>
<b>Historical ICTE policies</b>	Masterplan I (1996)
	Masterplan II (2001)
	Masterplan III (2006)
<b>Smart education-related policies</b>	Masterplan IV (2010): Smart Education
	Masterplan V (2014): Student Centred Learning
<b>Gross national income per capita (2019)</b>	\$44 390 (Rank 49 out 192 countries)
<b>Human Development Index (2019)</b>	0.916 (Rank 11 out 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	12.2
<b>Inequality Index (2021)</b>	0.307
<b>Government AI Readiness Index (2021)</b>	76.55 (Rank 10 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

Figure 10 provides a snapshot of the way smart education critical analytical framework themes manifest in South Korea's national AI strategy discussion paper (Republic of Korea, 2019).



**Figure 10. Smart education in South Korea's national AI strategy by its 4IR committee**

### Rationale

The rationale for a national AI strategy centres on the changes that AI is triggering and the future possible development of AI. The strategy draws on global and domestic trends where it highlights that the government has expanded its budget significantly to support innovative growth. Global policy trends related to AI are examined, particularly among the major global players, so that these can inform the need for a concerted AI strategy.

### Problem statement

The strategy states that South Korea faces a significant shortage of AI talent compared to leading countries, and it is expected that this shortage will be exacerbated because of increasing demand in the AI industrial field. How to attract AI talent and systematically develop AI skills and capabilities across the education and training system is therefore a priority.

### Vision

The strategy's vision is for South Korea to lead the world in the global AI sector.

### Strategic programmes

The strategy centres on innovating the education system so that the world's best talent can grow continuously and all citizens can make good use of AI. It involves significant investment in systematically building skills and capabilities across the national education, training and lifelong learning system.

#### *Establishing a system nurturing AI top talent and professionals*

This involves innovating the university system by, for example, creating and expanding AI-related departments. It includes:

- laying the foundation for a steady inflow of talented people by revising regulations affecting university operations;

- allowing the creation and expansion of AI-related departments using existing vacancy (100–300 students per year) and increasing the number of enrolments in the national universities if there is additional demand for such departments;
- establishing a customized incentive system by allowing AI-related teachers to take up positions in the private sector as subject experts;
- expanding the highest level of master's and doctoral level AI education and research programmes within universities;
- creating an AI sector in the four-stage Brain Korea 21 (2020-2027) courses and university-centred research institutes; and
- expanding and diversifying AI graduate programmes in a way that reflects the specific characters of each individual university.

It also involves providing various channels to nurture AI professionals, including short-term intensive curricula as non-degree courses and industry-specific customized curricula, in collaboration with industry.

### *Full-scale AI convergence in education*

The strategy further proposes the full-scale convergence of AI in its education system. This involves:

- easing the regulations in higher education to promote interdisciplinary majors that integrate AI and other majors;
- reinforcing AI in basic education to increase the number of students with both AI capabilities and expertise in other fields such as the humanities, medicine and the arts; and
- making AI education compulsory for all students at university and promoting AI-teaching among the professors based on a 'teach the teachers' model to scale the teaching across the national university system in the future.

### *Cultivation of AI technology sensitivity by occupational group*

The strategy also identifies the need to promote and cultivate awareness of and sensitivity to AI and its potential within particular occupational groups such as military personnel and public officers. The following actions are therefore proposed:

- Run AI basic literacy training courses for all military personnel.
- Use military massive online open courses (M-MOOC), military educational institutions and information education centres to provide education and training in AI.
- Provide in-depth education in partnership with the specialized training institution for the ICT-related training.
- Make AI literacy a mandatory course for both new and promoted public officials to enhance the awareness of AI in the public sector, with the goal of reaching at least 1,500 people per year.
- Expand the AI capacity training required at industrial sites for employees in all industries, including small and medium-sized enterprises (SMEs), venture companies and industrial complexes.
- Develop and operate industry-specific AI training programmes focusing on improving the proficiency and productivity of field workers.

The strategy calls for increased public awareness of AI and the creation of opportunities to grow national capabilities. South Korea plans to eradicate digital illiteracy around software and AI, but its software and AI education is currently still in the latent stage, which has led to a slew of missed educational opportunities for students and those who have left school. Plans to counteract this are described in the list above.

### *Systematic delivery of lifelong AI education*

A series of online and offline lifelong education courses is planned so that anyone can acquire AI literacy and knowledge. This involves creating AI programmes or courses within the academic credit bank system, evaluating the learning processes in accordance with the *Act on the Recognition of Credits*, and developing and providing various online education content, including massive open online courses (MOOCs) and cyber-university, so that adult learners can acquire AI competency.

### *Curriculum change and teacher development*

The strategy proposes a systemic revision of the school curriculum to give schools an AI focus. This involves implementing a giga-speed wireless network at elementary and middle schools across the country, and providing AI educational opportunities at various levels and locations outside of schools – for example, creating educational opportunities for vulnerable groups and rural residents, and training future instructors. The strategy also notes the importance of developing teachers' capacity by proposing support for teachers to undertake AI courses in their training and recruitment stages.

### *Governance and cybersecurity*

The strategy includes the establishment of a Fourth Industrial Revolution Committee as an AI-oriented pan-government committee. This committee is tasked with establishing an inter-ministerial collaborative system, supporting the establishment of follow-up plans for national strategies and conducting periodic inspections and evaluations. It will also comprehensively check and manage the resources for implementing the action plans and play a leading role in social discussions by, for example, holding an industry-specific regulation hackathon.

A key feature of the South Korean AI strategy is that it pays significant attention to the notion of creating trustworthy AI and establishing AI ethics. Measures to achieve this include:

- leading global discussions on AI ethics, including efforts to prepare the follow-up measures of the OECD's Recommendation of the Council on Artificial Intelligence;
- conducting R&D in order to develop new services and prevent dysfunctions resulting from AI development simultaneously, and establishing an inter-ministerial cooperative system; and
- establishing a quality management system that verifies reliability and safety in the wake of the proliferation of AI products and services.

### *Implementation action plan*

The strategy includes a detailed action plan that links 100 tasks to nine key strategies in the three areas of the AI ecosystem, AI use and people-centred AI. It also includes plans for each government ministry to incorporate the AI action plan in their respective ministerial plans.



### Potential gaps and tensions

The South Korean strategy is ambitious, comprehensive in its approach to educational system reform and matched with government budgetary investment. It reflects an understanding of the need for a comprehensive system overall if the country is to be a leader in an AI-dominated world. In this respect the strategy will have to contend with its plans to collaborate and engage internationally, thereby also managing tensions and geopolitical asymmetries at regional and global levels.

Large-scale system change and its management invariably create challenges, and the system must be prepared for the unexpected.

## United Kingdom

The national smart education policy case study for the United Kingdom draws on the country's 2021 National AI Strategy in which education, skills development and research commitments and plans are firmly entrenched (HM Government, 2021). The main focus in this document is on the strategy's education-related commitments. Table 13 presents a brief overview of the UK demographic and geographic context.

**Table 13. Demographic and education system information about the UK**

<b>Population (August 2021)</b>	<b>68 280 825</b>
<b>Historical ICTE policies</b>	Realising the potential of technology in education: A strategy for education providers and the technology industry (2019)
<b>Smart education-related policies</b>	National AI Strategy (2021)
	Scotland's Artificial Intelligence Strategy. Trustworthy, Ethical and Inclusive
<b>Gross national income per capita (2019)</b>	\$49 040 (Rank 26 out of 192 countries)
<b>Human Development Index (2019)</b>	0.932 (Rank 13 out of 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	13.2
<b>Inequality Index (2021)</b>	0.328
<b>Government AI Readiness Index (2021)</b>	81.25 (Rank 3 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

### Context

The UK's AI strategy reflects its long and exceptional history in AI, from the work of Alan Turing, one of the founders of the discipline and a lead AI scientist, to more recent pioneering inventions. It positions its 2021 AI strategy as the next step in that history, particularly in view of its position as third-highest in the world for private investment in AI and in terms of the global AI readiness index as shown in Table 13.

## Linkages to related policies

The strategy makes explicit reference to wide-ranging national policies, frameworks and strategies that have either already been adopted – for example, its plan for growth, innovation strategy, National Data Strategy and Plan for Digital Regulation – or are still in the pipeline – for example, its National Cyber Strategy, Digital Strategy and National Resilience Strategy.

## Statement of strategic intent

The strategy is articulated as the UK Government’s statement of strategic intent with the purpose of guiding its action plan over the next ten years. It also commits to developing a detailed and measurable execution plan that will be published in 2022.

## Definition

The strategy differentiates AI from other technologies by defining it as ‘machines that perform tasks normally requiring human intelligence, especially when the machines learn from data how to do those tasks’. It links its definition of AI to the legal definition adopted in the *National Security and Investment Act 2021*.

## Rationale

The rationale for the strategy is articulated in terms of:

- the potential of AI to transform the UK’s economy, improve people’s lives, transform industries and deliver first-class public services;
- AI’s being critical to the UK’s economic and national security;
- the UK’s need to prepare for the opportunities that AI brings and for the country to be at the forefront of solving the complex challenges posed by an increased use of AI;
- the leading role that the UK already plays globally in AI;
- the UK’s need to take the lead in addressing the challenges posed by AI, such as net zero, health resilience and environmental sustainability; and
- the UK Government’s strategy to strengthen its existing international influence as a global science superpower.

## Vision

The ten-year vision of the strategy is for the UK to maintain and build on its position as a global AI superpower. Its vision in this respect is to lead the world as a research and innovation powerhouse, a hive of global talent and a progressive regulatory and business environment and to be the ‘best place to live and work with AI with clear rules, applied ethical principles and a pro-innovation regulatory environment’.

## Strategy aims

The aims of the strategy are to:

- ensure that the UK remains an AI and science superpower for the next decade
- invest and plan for the long-term needs of the AI ecosystem to continue the UK’s leadership and position as a science and AI superpower;
- support the transition to an AI-enabled economy, capturing the benefits of innovation in the UK, and ensuring AI benefits all sectors and regions; and
- ensure the UK gets the national and international governance of AI technologies right

to encourage innovation and investment, and protect the public and the country's fundamental values. This will be best achieved by creating broad public trust and support, and by involving the diverse talents and views of society.

### Strategy goals, intended outcomes and impact

The strategy goals are for the UK to increase the number and type of made-in-the-UK commercialized discoveries, benefit from the AI-related economic and productivity growth and establish the most trusted pro-innovation system of AI governance in the world.

Linked to these goals are intended impacts and outcomes. The intended impacts include:

- The benefits of AI adoption are shared across every region and sector.
- The UK maintains its position as a global leader in AI research and development.
- The UK's AI sector grows, thus contributing to growth in the GDP.
- Fundamental national values are both protected and furthered.
- There are strong domestic AI capabilities to address national security issues.

The outcomes are structured around three strategic pillars as shown in Figure 11.

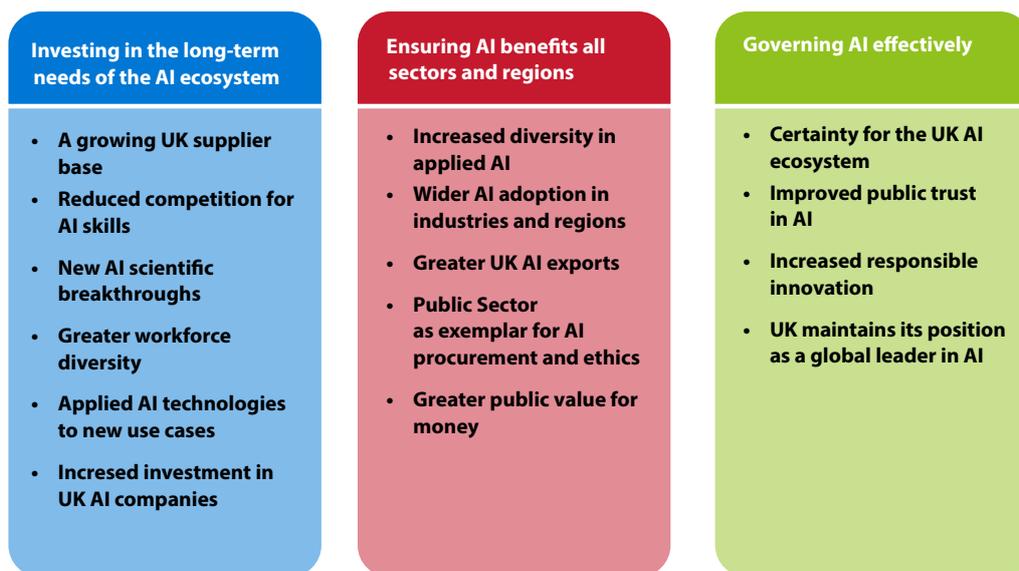


Figure 11. Intended AI strategy outcomes

### Skills and competencies

Developing and attracting AI skills and talent skills in the UK are central to pillars 1 and 2 in the AI strategy.

#### Significant and growing AI skills gap

The strategy acknowledges the significant and growing gap between the demand and supply of AI skills despite several new AI skills initiatives since the government's adoption of the AI Sector Deal in 2018. It reports that in 2020, there was a 16% increase in online AI and data science job vacancies and 69% of vacancies proved difficult to fill; there were significant barriers to recruiting and retaining top AI talent within the UK; and technical AI skill gaps were a concern for many firms.

To close the skills gap, the government will focus on attracting and training three groups of people:

- **Those who build AI:** The strategy is to grow the skills, talent and capabilities to build AI systems. This involves training and attracting the best and brightest at developing AI. To meet the demand seen in industry and academia, the UK Government plans to continue supporting existing interventions such as Turing fellowships, Centres for Doctoral Training and postgraduate industrial-funded master's degrees and AI conversion courses. In order to address the AI skills gap, the government had already embarked on a host of programmes and initiatives. For example, by 2021, 2,500 new master's conversion courses in AI and data science were being delivered across universities in England. These conversion courses provided people with the opportunity to develop new digital skills or to retrain in order to help them find work in the UK's cutting-edge AI and data science sectors.
- **Those who use AI:** The strategy is to engage employers and employees so that they can understand the opportunities for using AI in their businesses. It proposes to help employers identify their AI skills needs by using the Skills Value Chain approach developed by the Department for Education (DOE). The Office for Artificial Intelligence will work with the DOE to explore how these needs can be met and mainstreamed through national skills provision. The DOE will also organize skills bootcamps that include free, flexible courses for adults so they can develop sector-specific skills.
- **Those who want to be inspired by AI:** The strategy refers to the AI Roadmap, which identifies the value of encouraging interest in the potential of AI among people who do not use it and exposing children to AI through the National Centre for Computing Education (NCCE). The Office for Artificial Intelligence will also work with the DOE on career pathways for those working with or developing AI.

## Research

The strategy proposes an ambitious agenda for AI R&D, including the £46 million investment in Turing AI fellowships to attract, recruit and retain a substantial cohort of leading researchers and innovators at all career stages.

In line with the country's innovation strategy, the government plans to empower distinguished academics and invest in academic and industry partnerships to ensure students graduate with business-ready experience. The focus is on producing software engineers, data scientists, data engineers, machine learning engineers and scientists, product managers, and people who can perform related roles. The strategy aims to counteract the global competition to attract AI talent because of the current shortages in this area.

As announced in the innovation strategy, the government is revitalizing and introducing new visa routes to encourage innovators and entrepreneurs to come to the UK.

## Governance

The strategy also highlights the need to develop guidelines on the ethical design and use of AI systems. The government set up the AI Council to explore ways to encourage ethical and responsible approaches to AI.



### Potential gaps and tensions

It is evident from the UK's AI strategy that the government has invested significantly in a robust policy environment that covers wide-ranging interrelated issues. The strategy itself is ambitious and is part of a broader concerted effort to keep the UK in the top tiers of AI systems in the world.

One of the major areas of potential tension is that the ambitious plans and ideas outlined in the strategy will require significant investment and support for their implementation. Furthermore, the curricula for the skills development programmes have not yet been developed.

## United States of America

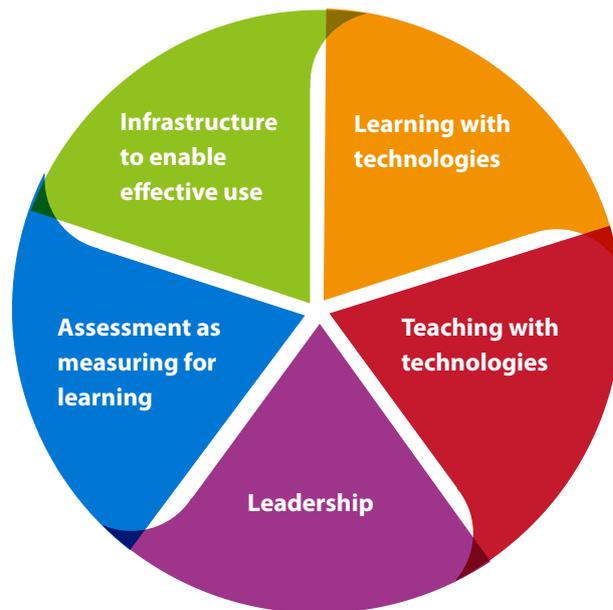
To date the USA has produced several reports on AI to support its development of a national AI plan, the aim of which would be to ensure that the USA remains a world leader in AI and that AI is enabled to strengthen economic growth and improve national security. To date, however, the country has no dedicated national strategy on AI, although there have been recommendations about increased federal funding, regulatory changes, the creation of shared public data sets and environments, and ways for AI to improve cybersecurity and various military processes. The focus in this document is therefore the USA's updating in 2022 of the 2010 National Education Technology Plan (Office of Educational Technology, 2017a). To set the USA case in context, Table 14 gives a brief demographic overview of the country.

**Table 14. Basic demographic and education system information about the USA**

<b>Population (August 2021)</b>	<b>333 151 370</b>
<b>Historical ICTE policies</b>	National Education Technology Plan (2010) National Education Technology Plan (2016) National Education Technology Plan Higher Education (2017)
<b>Smart education-related policies</b>	Updating National Education Technology Plan for 2021/2022
<b>Gross national income per capita (2019)</b>	\$66 060 (Rank 11 out of 192 countries)
<b>Human Development Index (2019)</b>	0.926 (Rank 17 out of 189 countries) – UNDP
<b>Mean years of schooling (2019)</b>	13.4
<b>Inequality Index (2021)</b>	0.378
<b>Government AI Readiness Index (2021)</b>	88.16 (Rank 1 out of 160 countries)

Sources: Oxford Insights (2021), UNDP (2019), World Bank (2021a), World Population Review (2021), Worldometer (2021).

Figure 12 provides a snapshot of the way the smart education critical analytical framework themes manifest in the USA's NETP.



**Figure 12. Smart education in the USA's NETP**

The NETP is written as a call to action and a vision for learning that can be enabled by technologies. It is aimed at teachers, teacher preparation professionals, policy-makers and administrators. Its vision is for learning everywhere, all the time. It focuses on a few key themes: learning with technologies, teaching with technologies, assessment with technologies, the technological infrastructure needed in schools and districts and the centrality of leadership. It analyses the issues and the changes taking place as a result of technology integration in learning, teaching and assessment and makes recommendations for its target audience to consider. It also intersperses its analyses and recommendations with practical examples of technology integration within each of its themes.

## Problem statement

The NETP both acknowledges the strides that have been made since 2010 and highlights the need to address persistent problems. Some of the latter include the persistence of digital inequality and prevalence of a digital use divide; the small number of schools and districts that have adopted technology to support informal learning; the high number of pre-service teachers who feel unprepared to use technologies to support student learning; assessment approaches that still do not use technologies to their full potential; and growing concern about network security as internet-accessible school data, management and learning systems become more ubiquitous and the sophistication of attacks, including the use of ransomware, on school networks grows.

## Overall framework

The NETP framework centres the educational technology plan on using technologies to provide engaging and empowering learning approaches, developing assessment approaches based on understanding learning progress, and encouraging leadership to set the vision. This requires the appropriate infrastructure to be in place in order to provide technological accessibility, connectivity, and resources to enable learning everywhere all the time.

## Goals

The NETP clarifies each theme's goals explicitly.

- **Learning with technologies goal:** 'All learners will have engaging and empowering learning experiences in formal and informal settings that prepare them to be active, creative, knowledgeable, and ethical participants in a globally connected society' (Office of Educational Technology, 2017a, p. 9).
- **Teaching with technologies goal:** 'Educators will be supported by technology that connects them to people, data, content, resources, expertise, and learning experiences that can empower and inspire them to provide more effective teaching for all learners' (p. 28).
- **Leadership goal:** 'Embed an understanding of technology-enabled education within the roles and responsibilities of education leaders at all levels and set state, regional, and local visions for technology in learning' (p. 42).
- **Assessment as measuring for learning goal:** 'At all levels, our education system will leverage the power of technology to measure what matters and use assessment data to improve learning' (p. 55).
- **Infrastructure to enable active and effective use goal:** 'All students and educators will have access to a robust and comprehensive infrastructure when and where they need it for learning' (p. 69).

### *NETP theme: Learning with technologies*

The learning with technologies theme is focused on the USA's remaining globally competitive and developing engaged citizens with twenty-first-century competencies and expertise throughout the learning experience. These competencies include critical thinking, complex problem-solving and collaboration, and required, among other things, adding multimedia communication into the teaching of traditional academic subjects. This theme highlights the need for learners to develop agency in their learning and the belief that they can succeed in school, as well as a range of non-cognitive competences such as forming relationships, solving everyday problems, and developing self-awareness, executive function, self-care and care for others.

This theme highlights four ways in which technologies can improve formal and informal learning: they can enable engaging, relevant, personalized learning pathways; help learning beyond the classroom; open transformative learning possibilities for all learners; and enable multiple means of expression so that learners can demonstrate what they know.

The NETP makes a host of recommendations such as that states, districts and postsecondary institutions need to implement learning resources in ways that are flexible, equitable and accessible; that embody design principles from the learning sciences; and that take stock of and align learning technologies with intended learning outcomes.

### *NETP theme: Teachers as co-learners – teaching with technologies*

The NETP frames teachers as co-learners with their students who can develop new and deeper learning experiences when teaching with technologies. It provides an overview of different ways that teachers can support and inspire learners – for example, they can collaborate with their peers and their students beyond the classroom; design engaging and relevant learning experiences with technologies; guide, facilitate and motivate their learners; and help under-served learners meet their needs.

It also proposes that teachers need to leave teacher preparation institutions with a solid understanding of how to use technologies to support learning and that they need to be

supported with ongoing professional development. The Office of Educational Technology offers four guiding principles on advancing educational technologies in teacher preparation:

1. Focus on the active use of technology to enable learning and teaching through creativity, practical experiences and problem-solving.
2. Build sustainable, programme-wide systems of professional learning and teaching.
3. Ensure pre-service teachers' experiences with educational technology are programme-deep and programme-wide, rather than one-off courses separate from their methods courses.
4. Align activities related to technology-enabled teaching and learning with research-based standards, frameworks and credentials recognized across the field.

Its recommendations to decision-makers include that pre-service and in-service teachers be provided with technology-enabled professional learning experiences and training in online and blended instruction; and that a common set of technology competency expectations be developed to guide pre-service and in-service teachers and teacher educators.

### *NETP theme: Leadership*

The NETP's focus on leadership is aimed at creating both a culture of and the conditions for innovation and change in education institutions. It provides an overview of the characteristics of effective leadership – for example, fostering a shared vision of how technologies can support learning, communicating with all stakeholders using media and technologies appropriately, ensuring that policies and resources equip teachers with the right tools and support and that teachers are encouraged to collaborate to make instructional decisions based on diverse data sets, and encouraging teachers and leaders to engage in collaborative inquiry to build the capacity of staff and the institution as a whole through a range of learning modalities.

### Budgeting and finance

The NETP also provides guidelines on budgeting and financing education districts' transition towards becoming digital learning districts, as financial challenges are often prevalent when implementing technology programmes. It proposes identifying areas in existing budgets where spending can be reduced and exploring possibilities for creative funding. It also recommends using budgeting and financing strategies that entail:

- eliminating and reducing existing costs;
- forging partnerships to secure resources;
- making full use of federal funds; and
- ensuring long-term sustainability of technology investments.

It further recommends that clear strategic planning connections be made at all levels – that is, from school to state levels – on how they relate to and can support learning with technologies; that a vision be developed for technology-enabled learning; that funding models and plans for sustainable technology purchases be put in place; and that communities of practice for education leaders be developed at all levels.

### *NETP theme: Assessment – measuring for learning*

The NETP shows how assessment approaches are shifting from traditional ways of assessing learning towards emerging ways of assessment. The latter focuses on the use of assessment data for learning and how technologies can enable enhanced question types, the measurement

of complex competencies and adaptation to the learner's ability and knowledge when assessment is embedded in the learning process provide, and provide real-time feedback.

It recommends that learners' privacy and data of be protected while enabling a model of assessment that gathers and shares data on an ongoing basis; that learning dashboards be implemented as response systems and communication pathways between students, teachers and their families; that integrated systems for the assessment of complex competencies be implemented and ongoing research to improve the integration of assessment technologies conducted on an ongoing basis.

### NETP theme: Robust infrastructure

The NETP makes a case for the development of equitable, accessible robust technology infrastructure across education institutions. It proposes:

- ubiquitous connectivity that provides consistent access to high-speed internet in and out of school;
- powerful mobile learning devices that connect learners and educators to the vast resources of the internet and facilitate communication and collaboration;
- high-quality digital learning content and tools that can be used to design and deliver engaging and relevant learning experiences; and
- responsible use policies (RUPs) to guide and safeguard students.

It recommends that students and educators have broadband access to the internet and adequate wireless connectivity, with a special focus on equity of access outside of school; that every student and educator has at least one internet-accessible device and appropriate software and resources for research, communication, multimedia content creation and collaboration for use in and out of school; that there is support for the development of openly licensed educational materials; and that a comprehensive map and database of connectivity be created.



#### Potential gaps and tensions

The NETP offers practical guidance to key decision-makers at all levels of the national education system in the USA. It draws on the experience of its 2010 NETP and laid the foundation for supporting the pivot to remote and digital learning during the COVID-19 pandemic.

The research literature recognizes the value and centrality of equity and accessibility imperatives of the NETP and its emphasis on growing the transformative agency of learners, particularly those from under-served communities. It also highlights gaps in the plan to manage the predominance of private technology companies and their commercialized EdTech products and the need to be mindful of the risks of promoting corporate and private interests in education (Wiebe et al., 2021).

## Policy implementation case studies

This framework identified fifteen cases of policy-linked interventions that relate to the way emerging smart education policy is being implemented by governments and their partners. The case studies are structured along the implementation mechanisms and policy themes highlighted in the critical analytical framework discussed earlier in this document.

Consistent with the critical approach of the analytical framework on smart education, the case study interventions also include questions for further investigation about the efficacy and

effectiveness of the intended outcomes, particularly insofar as they relate to the stated policy goals and, more broadly, the Sustainable Development Goals.

## Policy theme: Infrastructure

Before the outbreak of the COVID-19 pandemic, ministries of education across the world were preoccupied with promoting access to digital technologies to learners, teachers, and administrative and management staff. Large-scale digital device roll-out programmes were central features of policy implementation plans as shown by Trucano (2015). Trucano examined eleven countries that had started government-led tablet initiatives and took predominately device-led, tech-centred approaches instead of evidence-based pedagogically centred approaches. Since then, a few countries have taken stock of the limitations of past implementation strategies and attempted to make improvements. One programme of interest in this respect is the Early Digital Learning Programme (EDLP) in Mauritius.

### Case study 1: Tablets for Grades 1 and 2 learners (Mauritius)

The Mauritian government has made attempts at improving the digital infrastructure in its schools for many years. In 2002–2003 it established computer rooms in its primary schools, and by 2018, every school in Mauritius had at the very least a computer room with an average of twenty personal computers (PCs), a printer and a digital projector. The Ministry of Education faced the challenge of software and operating systems becoming obsolete and learned that they needed to plan for effective technical maintenance and support as part of their digital technology roll-out programmes. In 2011, via the French Government-supported Sankoré Project, the ministry distributed 1 109 laptops and digital interactive projectors to schools.

In 2018, the ministry, supported by the Indian Government, distributed 26,800 tablets with preinstalled education content to Grade 1 and Grade 2 students as part of its Early Digital Learning Programme (EDLP). The EDLP was part of a renewed smart classrooms strategy of the Mauritian Government that focused on enabling early learners to engage in digital learning.

Importantly, the design of the EDLP drew lessons from a 20,000-tablet distribution programme targeted at Grade 10 students a few years previously. The tablets reportedly malfunctioned and were withdrawn (Defimedia, 2018).

Hurreeram and Bahadur (2019) conducted a qualitative study with a purposeful sample of twenty-three teachers on their use of the EDLP tablets for learning and teaching. They found that while more teachers reported notable learning improvements among most of their students, the teachers themselves were not yet making optimal use of the tablets to support their teaching practice. They conclude that particularly in the early learning years, teachers remain central to ensuring the optimal use of tablets for learning and that their ongoing training and professional development in the pedagogical use of technologies is paramount for success.



#### Potential gaps and tensions

The Mauritian case study shows that technology roll-out at scale is a complex endeavour that requires political will, leadership, careful planning and effective implementation strategies. It also shows that challenges arise at the procurement level and when making choices about digital infrastructure – in this example, the government purchased low-quality tablets that malfunctioned. This highlights the need for fair and robust procurement processes that specify technology standards that must be met by any equipment purchased.

## Policy theme: Curriculum and pedagogy

An emerging policy implementation theme is the investment in exponential technologies to support curriculum change and shifts in pedagogy and assessment practices. Case studies 2–4 detail examples of this.

### Case study 2: Datafication of assessment – blockchain in unified state exam (Russia)

Blockchain is a reference to a string of blocks of information that build on top of one another in a chain. Blockchain technologies are sometimes referred to as distributed ledger systems (DLS) which means that the same data are stored and distributed on and across a range of different computer systems. The ledger is publicly available, publicly distributed because it is divided into different locations and publicly replicated on thousands of computers; it is operated and verified by a network of decentralized people or institutions, none of whom may know one another or agree with each other when using a public blockchain. Data records are combined as a block and stored in encrypted form.

According to the OECD (2021), blockchain ranks among the more mature technologies but its application in learning and teaching is limited to date. Blockchain technologies are purported to offer a reliable user-friendly credentialing system and help unbundle institutional monopolies. For the OECD, as analysed by Smolenski (2021), the primary value of blockchain for education is that it makes credential verification faster, cheaper and more secure. It enables individuals, institutions and systems to validate qualification claims instantly and accurately. When used in combination with open standards, blockchains remove ongoing dependencies on issuing institutions, software providers and third parties to verify official records. Moreover, they enable direct ownership of digital credentials by both issuers and recipients.

The technological affordances of blockchain lie in the volume, velocity and veracity of the credentialing data that it can manage. It enables individuals or institutions to validate claims about qualifications instantly and with a high level of certainty and provide data-intensive feedback on ways in which upskilling, reskilling and between-job mobility can take place (OECD, 2021). These are some of the affordances of blockchain in which the Russian unified state exam system sought to invest. In 2019, the Russian Federal Service for Supervision in the Sphere of Education and Science indicated its plans to implement blockchain technology in the country's main graduation examination, the unified state exam, in Russian universities. The blockchain system is intended to introduce new ways of evaluating and credentialing student knowledge and capabilities.



#### Potential gaps and tensions

The existing research highlights the value and affordances of blockchain technologies for education. However, because it is considered a disruptive technology, its adoption will invariably create challenges related to democratizing and automating the learning process and making institutional systems more efficient.

The challenges and tensions that may be encountered are likely to include the need for universities to protect data systems from external stakeholders. In addition, administrative structures within universities may be streamlined, thereby reducing costly administrative bureaucracies, which may be perceived as a negative in some quarters as it could lead to job loss, and it will likely take time for users to trust the technologies. Added tensions that may arise also relate to the environmental cost of blockchain investment in education in view of the significant amount of electricity that it takes to run complex code across many computers (Haugbakken and Langseth, 2019).

### Case study 3: Machine-based School Dropout Early Warning System in India

Over the past few years, early warning technologies that identify and track learners who are disengaged and at risk of leaving school (UNICEF and UNESCO-UIS, 2016) have become more sophisticated and data-intensive. These technologies have come to be called early warning systems (EWS) and early warning indicators (EWI) (OECD, 2021). They are an example of a system used to harvest and extract students' educational and personal data by applying data mining, machine learning and statistics to data generated in schools, colleges and universities and intelligent tutoring systems based on the increasing computational capacity of the technology systems. It is widely believed that when they are accurately trained, early warning systems have the potential to provide more complex, reliable, accurate and timely predictive analytics in large volumes about students who are at risk of leaving formal education institutions. These data can be used to help teachers, system managers and administrators respond in a timely, supportive and appropriate way to circumvent and prevent dropout. Many governments have developed dropout early warning systems for this purpose. For example, the state of Victoria in Australia introduced a student mapping tool (SMT) to help schools identify students at risk of disengagement and dropout, and the state of Wisconsin in the United States developed its Dropout Early Warning System (DEWS) to predict dropouts (Lee and Chung, 2019).

In 2015, the government of Andhra Pradesh in India signed a memorandum of understanding with a major multinational technology company to use its machine learning platform to develop an application designed to predict school dropouts. The application processes complex data sets that include details about enrolment, student performance, gender, socio-economic demographics, school infrastructure and teachers' skills to find predictive patterns. The application proactively identifies students at risk of leaving school and produces an analysis of the critical factors responsible for the issue. More than sixty patterns have been identified.

During the academic year 2018–2019, the platform identified 19,500 students in its Vishakhapatnam district who were at risk of dropping out of school. The application revealed that the most influential factors were learning outcomes (57%), infrastructural factors such as the lack of or limited furniture and inadequate toilet facilities (31%), transitional factors (7%), age inappropriateness (4%) and social status (1%). These results informed tracking and counselling strategies at the schools and led to campaigns by the government on the advantages of public school attendance among students and parents. (India.AI, 2019; Rao, 2018).

This case study thus demonstrates how the policy goal to use enabling technologies to curtail the growing school dropout challenge was implemented in practice, via the investment in a big data machine learning application.



### Potential gaps and tensions

Integrating machine learning-based early warning systems (EWS) in education may have the potential to improve system knowledge about student disengagement, absenteeism, truancy and dropout. It could therefore improve both predictions about which students are at risk of dropout and understanding of the systemic push factors that drive learner absenteeism, disengagement and dropout. However, there is a risk of treating the data-intensive algorithmic system as a panacea for addressing the student dropout crisis. The causal factors that drive student disengagement often involve more complex combinations of systemic social, economic, psychosocial and political influences which require more nuanced leadership and responsiveness to tackling dropout and keeping learners in education systems in a meaningful way.

The accuracy of the indicators used is a further concern. Bowers (2021, cited in OECD, 2021, p. 174) has shown that comparisons of predictive indicators used across various EWS need to be refined as they also run the risk of 'misidentifying' cases.

Additionally, institutions that are rich in data about their students do not always make effective and appropriate use of the data in ways that support and nurture student academic learning and well-being to keep them in school, college or university. The use of complex data is a specialized skill – this raises both the need for skilled capacity to produce and manage the data and the risk of institutionalizing divisions between those involved in producing and managing data and those who are at the receiving end of the use of data. The latter will also require institutional investment in appropriate skills development and capacity-development to make relevant, ethical, equitable and efficient use of the data provided by the early warning systems.

Moreover, the data-intensive early warning systems as products of global multinationals create the risk not only of students' personal data being available to private companies but also of covert forms of monitoring and surveillance of students and their behaviour being used. Thus, policy implementation projects of this kind will also need to consider ways to protect the private and personal data of students to safeguard their privacy and counteract their potential use for surveillance purposes.

### Case study 4: AI basics and AI mathematics as subjects in the K–12 curriculum (South Korea)

South Korea is among the first few countries in the world to have taken steps towards embedding AI in specified elementary school curriculum subjects. For example, an AI-based mathematics learning program titled Knock! Knock! Math Explorers – sometimes translated as Math Expedition in English – was developed by the Ministry of Education and distributed to elementary school students in Grades 1 and 2 across the country on 14 September 2020. This AI program analyses the results of a quiz that students take after learning a specified topic from their maths textbooks and the mathematics curriculum, and then recommends specific learning content tailored to the learning needs of the student. In this way, the curriculum content matches the learning level of each student based on an assessment of their ability to perform textbook-based assignments. The program mainly consists of playful number games to keep young students focused on learning. It is anticipated that the program will reduce educational disparities by enabling students to study anywhere – including in schools, at home and overseas – and expand learning opportunities during future lockdown conditions similar to those experienced during the COVID-19 pandemic.

At the time of writing, as a pilot programme, it is in operation in five schools in South Korea (Seoul, Daegu, Gyeonggi, Chungnam and Gyeongbuk) and the plan is to distribute it to thirty-four Korean schools in other countries around the world.



### Potential gaps and tensions

AI curriculum development in the K-12 schooling sector is still in its infancy and to date only a few countries across the world have taken steps towards it. The current expectation is that a host of debates and tensions are likely to arise from state capacity to design, develop and implement AI curricula in the schooling system; capacity to integrate AI curriculum teaching in both national initial and continuous teacher professional development systems and the philosophical pedagogical underpinnings of curriculum reform and the integration of AI in the curriculum in ways that promote the overall aims of the Sustainable Development Goals; and the management of market-driven, private sector driven, product-centred orientations in AI curriculum design. The design and implementation of AI curricula will likely also add a layer of complexity to curriculum design and delivery in many countries.

The introduction of AI to the elementary school curriculum by the South Korean Ministry of Education (MOE) represents an extension of South Korea's development of AI Basics as part of its high school curriculum for Technology Home Economics and AI Mathematics as part of the mathematics curriculum in high school. AI Basics and AI Mathematics were introduced as elective subjects in career-pathway programmes in high schools across South Korea in September 2021. According to UNESCO (2022b), this curriculum has the potential to reach 2,367 high schools. South Korea reportedly also has 500 'AI education leader' schools, which are focused on cultivating talent in the technology sector.

For elementary and middle schools, the South Korean Ministry of Education (MOE) and local-level education offices (at metropolitan and provincial levels) plan to implement a combined education programme that integrates the AI curriculum into the existing software coursework. In addition, the MOE is developing AI-related course materials for distribution and use in K-12 schools. According to the MOE's plan, the updated curriculum will be implemented throughout the country and AI education fully adopted in all K-12 schools by 2025.

## Policy theme: Digital education resources and platforms

The design and use of digital education resources and platforms as part of an endeavour to promote access, quality, equity and efficiency in education has been clearly articulated in policy. Case studies 5 and 6 concern the innovative and dynamic use of a hybridized platform in China and an approach to open educational resources in the USA, respectively.

### Case study 5: Online-merge-offline (OMO) learning (China)

This case study is based on the education sector's repose to COVID-19 in China and aligns with the policy theme of digital education resources and platforms and the policy theme related to curriculum and pedagogy within the critical analytical framework.

In China, the Ministry of Education adopted an online-merge-offline (OMO) learning approach not only as a response to the COVID-19 crisis but also as a basis to prepare the education system for an infrastructure that allows online and offline learning to take place simultaneously for students who are learning remotely and students who are physically present in the classroom. It involved the use of a smart learning tool, ClassInX, interactive smart boards, sound equipment, cameras and a selection of devices. Together, these technologies make possible the simultaneous delivery of both online and offline learning in real time. Integral to the OMO approach are teaching and learning practices that leverage open educational resources (OER) that can be retained, re-used, revised, remixed and redistributed because they are openly licensed. In this way, the OMO learning approach also embraces open education practices (OEP) by incorporating the optimal use of classroom and remote spaces for learning, technological integration and pedagogical practice (Huang et al., 2021).

The OMO learning system was explored over a three-month period from three dimensions: space design considerations, technological considerations and pedagogical considerations. The qualitative study based on the three-month experiment found that teachers and students had a positive attitude towards OMO learning. However, it also emerged that teachers needed a more comprehensive set of core and functional competencies – including the use of online platforms, communication skills, class management and the effective use of resources – and that more attention should be paid to classroom design, such as infrastructure, to efficiently support OMO learning. This study provides insights into future hybridized learning designs that can be sustained in the face of an increasingly crisis-prone world. (Huang et al., 2021).



### Potential gaps and tensions

The study on the OMO experiment reveals an innovative approach to hybridizing and blending the digital classroom as a system and the way physical space combines with platform design, teacher support and the use of appropriate pedagogies. It also revealed gaps in building teachers' competencies and preparing them to teach in such hybridized settings under emergency conditions, which in turn revealed the importance of engaging with the mental and social-emotional challenges that accompany crisis conditions. Teachers need to be able to collaborate with learners and the caring adults in their lives such as parents, guardians and older siblings. They also need to learn how to engage with physical and virtual learning spaces simultaneously, a skill that is likely to be gained over time with experience. In this respect, the experiment with an OMO hybridized innovation points to what is possible and what will be needed to make such an intervention work at institutional and system-wide levels.

### Case study 6: #GoOpen USA

The US Department of Education's #GoOpen initiative helps school districts in the USA to systematically transition to the use of openly licensed educational resources in the curriculum to transform teaching and learning. It is directly linked to the National Educational Technology Plan. Districts that choose to become a #GoOpen District have district-level teams that plan, strategize and organize the implementation of openly licensed educational resources and any associated plans and strategies. #GoOpen implementation teams often include classroom teachers, curriculum directors, librarians, educational technology directors and administrators. An important activity of a #GoOpen district-level team is to assess its district's needs and opportunities and determine specific actions that will best serve the district in the transition to openly licensed educational resources.

The initiative runs like a campaign with clear advocacy messages. It challenges schools to begin by replacing just one textbook with openly licensed educational resources as a first step in appreciating the cost savings and developing an understanding of what they would need to implement such a change school- or district-wide. Participating districts have access to resources to help them make the transition.

#GoOpen Ambassador Districts have already taken steps towards the transition and commit to:

- mentoring at least one #GoOpen Launch District – a district that is in the early stages of making the switch to openly licensed educational resources – as it designs and implement its strategy for its transition to using openly licensed educational resources;
- developing plans to ensure the continued scalability and sustainability of openly licensed educational resources; and
- openly license and share their resources, and share information and insights about their #GoOpen process with other districts.



### Potential gaps and tensions

The potential gaps and tensions that may arise from the campaign for districts to commit to openly licensing their educational resources could depend on the particular open licensing regime that is being adopted. There is also a risk that an open licence can serve as a smokescreen for commercializing open educational resources. Research on the open licence transition and experiences of districts, schools and teachers with this process would therefore be worth monitoring.

## Policy theme: Skills and competencies

### Case study 7: Microcredentials for teachers in Dysart Unified District (USA)

In the USA, a growing number of districts have been piloting the use of microcredentials to complement state and district policies on personalized professional development for teachers. Digital Promise, an NGO, worked with wide-ranging education institutions in promoting microcredentials in teacher development. By 2019, more than fifty universities, non-profits and school districts in the USA had developed more than 400 microcredentials covering a wide array of professional skills for teachers. The National Education Association (NEA) launched its micro-credential work in the autumn of 2017 and since then has worked in partnership with Digital Promise to develop more than 150 microcredentials and create a platform for its members in state and local affiliates to be recognized for formal and informal learning.

By 2019, ten state education agencies had also launched and an additional five had been experimenting with microcredentials in official microcredential pilots. In addition, another five states – Illinois, Maryland, Montana, New York, and Wyoming – are experimenting with microcredentials in some way. The Professional Education Standards Board in Washington had also offered grants to agencies that wanted to experiment with microcredentials. The state of Tennessee's pilot on microcredentials, for example, reached 800 educators in more than twenty-five school districts. In the Dysart Unified School District, Maricopa County, Arizona, teachers can earn substantially more money if they earn microcredentials: they can expect a 4 per cent raise if they successfully complete fifteen microcredentials and another 4 per cent raise if they complete a second batch of fifteen (Digital Promise, 2021).



### Potential gaps and tensions

Challenges may arise when making attempts at slicing up bundled pre-designed learning programmes into sub-units to facilitate microcredentialing. They may also arise when different courses and programmes, each with different course descriptions and differently stated learning outcomes, are compared and there is lack of trust about the quality and efficacy of professional development courses for teachers.

### Case study 8: AI for Everyone (Singapore)

The Singapore Government launched the AI for Everyone initiative as part of its AI strategy. The initiative serves to encourage all citizens to enrol in AI programmes that are available on a dedicated AI for Everyone portal called LearnAI. According to government officials, most Singaporean citizens will have their first exposure to AI through the AI for Everyone initiative. Along with enabling its implementation in Singapore, the government also partnered with the Ministry of Communications and Information Technology in Egypt to run a similar programme in Egypt. The LearnAI portal makes available a wide range of free online short courses that target different audiences, including children. Their topics include, for example, learning about modern AI applications and building AI models with online tools, practising the creation of AI models that can predict student grades, and use cases of applying AI in business (Lago, 2018).

AI for Students (AI4S) and AI for Kids (AI4K) are specifically aimed at students. Teachers can also access courses, and they can request six months' access to DataCamp for their students. The courses for students are tailored for primary schoolchildren aged 9–12 (AI4K) and secondary school to university students (AI4S). For example, the Grade 1 level in AI4K is a beginner course that includes the following type of topics:

- Introduction to machines and computers
- Problem-solving and algorithms
- Sequences and loops
- Selection statements
- Code and functions
- Introduction to AI

The LearnAI portal also offers a premium annual subscription targeted at industry for programmes such as its AI for Industry (AI4I) programme and a one-year subscription to DataCamp.

### Case study 9: AI for Apprenticeships (Egypt) programme

The Egyptian Ministry of Communications and Information Technology partnered with the Singapore Government to learn from its experience with developing AI talent among youth and advancing their career opportunities in AI-related fields. These activities involved engaging with industry not only to open up employment opportunities for youth but also to give businesses the opportunity to enhance both their AI and machine learning skills base and their use of software engineering in the deployment of AI models in production.

The programme includes full-time structured training programmes, short courses on deep-skilling in AI engineering and a few months' on-the-job training in real-world AI problems. The plan is to include a training allowance, as was done in Singapore.



### Potential gaps and tensions

The potential tension that may arise with short-term apprenticeship programmes is that they may not translate into the comprehensive acquisition of skills because skills and skills development often involve a process of development over time, especially in their application in complex real-world settings. The challenge may also be exacerbated by the skill-intensity of the AI field.

The International Labour Organization's (2017) review and analysis of apprenticeship programmes across the world showed that there is no single, standardized definition of apprenticeship training across countries. This suggests different countries may have varying conditions, legal frameworks and practices for apprenticeships in terms of support.

Depending on the programme design, only relatively few apprentices may find work after their training, suggesting that it is not often a model that can scale over a short period of time.

## Policy theme: Governance

How governments have planned to implement human, safe and ethical projects and programmes that are linked to national strategies and policies on AI has become a critical area of concern and interest.

### Case study 10: Scottish AI Alliance (UK)

The government of Scotland strongly emphasizes the development and use of trustworthy, ethical, and inclusive AI in its national strategy. To realize these objectives, the Scottish AI Alliance has an open-to-all stakeholder groups with representation from across society that will deliver on the strategy's vision and actions. The Scottish AI Alliance offers a vehicle for everyone's participation, including children. The Alliance considers children as social beings with agency and the right to participation in decision-making. It has established decision-making and leadership structures based on four Circles – Leadership, Delivery, Community and Support – and adopted an outward focus to engage with stakeholders and partners across the UK and internationally, including in the European Union (DataLab, 2021).

By early 2022, the Alliance had established systems for engaging multiple partners and strategic stakeholders – including stakeholder groups engaged with youth and children to ensure that stakeholders who are often excluded have their voices heard and their interests included – to support the delivery of Scotland's AI strategy. It has mobilized Scottish industry leaders to support awareness-raising and skills development plans among employers. The latter includes addressing employers' and employer associations' reluctance to embrace AI because of limited and limiting perceptions about it.



### Potential gaps and tensions

Alliances and partnerships can be challenging when multiple stakeholders are involved and when varying interests and power relations prevail. Managing conflicting interests and managing multiple perspectives will require investment in strong alliances and the development of partnership leadership. The latter can be instrumental in managing the complexity of multistakeholder, multipartner alliances.

## Policy theme: Management and administration

A key feature of national ICTE and smart education policies is the establishment of national education management information systems. South Korea has developed one of the most extensive national EMIS systems via its successive national ICT masterplans, as described in case study 11.

### Case study 11: National education information system (South Korea)

In South Korea, the National Education Information System (NEIS) is the information system developed in 2001 to help the Ministry of Education (MOE), seventeen regional education offices and over 10,000 primary and secondary schools better facilitate education administration. In 2001, the NEIS was selected as one of eleven major projects for the government's digital masterplan to collect diverse data that will prove valuable for teachers, parents and students in the context of education. Over the years, the NEIS has become more sophisticated. By 2013 it included online school surveys, student psychological analyses, and behavioural characteristics surveys in cooperation with its Ministry of Health and Welfare to build support systems for academically disadvantaged groups. In 2014, it shifted gear to include a host of additional services, including graduate school records digitalization, career options for students, and the provision of online resources for qualified individuals sitting exams. It now contains records on every student and teacher in South Korea.



#### Potential gaps and tensions

The potential tensions in relationship to an effective national education information system relate to the privacy of the data that the system hosts for teachers and students. The system invariably has access to sensitive information about learners and teachers which poses risks of exposure and breaches of personal data protection unless the system has a built-in strategy to safeguard the data.

## Policy theme: Partnerships

### Case study 12: #Shift Digital Partnership (South Africa)

The #Shift Digital Partnership involves a range of youth digital skills academies in South Africa: Harambee Youth Employment Accelerator, Cape Innovation and Technology Initiative (CiTi), Explore Data Science Academy, WeThinkCode, Tshimologong Precinct Digital Skills Academy and the Joburg Centre for Software Engineering (JCSE) at Wits University. The partnership combines the collective experience of all the participating institutions and has designed strategies to move young people into digital jobs in an accelerated, agile and responsive way to meet the demands of the digital economy. The partnership recognizes that traditional pathways into digital roles are time-consuming and expensive, which means they are not producing enough digital talent fast enough. It therefore seeks to increase the supply of skilled youth through more cost-effective, inclusive and scalable pathways (Harambee Youth Employment Accelerator, 2021).

The strategies include mobilizing youth from under-served communities to participate in wide-ranging computational courses on, for example, coding, robotics and data science, and opening up employment and entrepreneurial pathways by engaging employers and small and medium enterprises to allow spaces and opportunities for internship. Internships are believed to provide important entry points for exposure to the world of work and are an important foundation for future employability. Internships often last for six to twelve months.



### Potential gaps and tensions

One of the potential gaps and challenges that youth partnerships like these are likely to encounter is the sustainability of youth employability following the skills training programmes. Often skills training programmes are one-off short-term courses. The digital partnership can learn from the experiences of its member organizations with short-term youth digital skills programmes and subsequently explore strategies for continuous support during and following digital skills internships.

### Case study 13: California Community Schools Partnership Program (USA)

Another form of partnerships is the emergence of state-authorized community school partnerships. The California Community Schools Framework (CSBE, 2022) on school improvement, adopted by the Californian State Board in the USA, incorporates the creation and development of partnerships with various stakeholder communities within and beyond the school. The partnerships facilitate programmes via local education agencies that involve close collaboration between educators, students, their families and a range of health and social support agencies to understand and address the unique needs, assets and aspirations of the school community.

Community schools take a 'whole child' approach to education and design their own curricula and programmes to this end. They partner with community-based organizations and local government agencies to use community resources to realize a shared vision for success. They also focus on addressing each student's academic, cognitive, physical, mental and social-emotional needs and prioritize the development of a nurturing, trusting school environment. They are guided by principles of equitable whole child practices that are grounded in the science of learning and development. Each feature of a community school contributes towards a child-centred approach where the full scope of the child's well-being is prioritized in ways that promote healthy development, learning and thriving.

Some community schools are open beyond the hours of the traditional school day for after-school activities which often include tutoring and enrichment activities for children, workshops and community services. Many community schools operate year-round to serve both children and their families. They are designed to intentionally and collaboratively address the economic and social barriers that are the underlying cause of the opportunity and achievement gaps.

In its 2022 budget, the Californian Legislature allocated US\$3 billion to implement the California Community Schools Partnership Program. This figure includes US\$142 million for regional technical assistance centres to support the management of logistics including surveying neighbourhoods to identify assets, strengths and gaps in services.



### Potential gaps and tensions

Multistakeholder partnerships are important for systems to function, but they can also be challenging to manage and difficult to sustain. At the level of signing and celebrating educational technology partnership agreements, there are many success stories. However, at the level of their implementation and management, many challenges, tensions and contradictions come to the fore (Isaacs, 2021). Strategies to ensure good partnership management are often based on experience and are often situational. Sustaining partnerships requires constant monitoring and continuous improvement.

## Implementation theme: Research, innovation and evaluation

A key feature of smart education policy implementation is how it is linked as a sectoral policy to transversal national strategies that include the establishment of dedicated institutes and centres to build skills and grow cultures of innovation through research and development. Case studies 14 and 15 offer two examples of this.

### Case study 14: Centre for Artificial Intelligence Research (South Africa)

The Centre for Artificial Intelligence Research (CAIR) is a distributed South African research network with nine established and two emerging research groups across eight universities funded primarily by the South African Government Department of Science and Innovation (DSI). While the CAIR was established in 2011 with the aim of building world-class AI research capacity in South Africa, its mission aligns with the most recent recommendations of the Ministerial Task Team on the Fourth Industrial Revolution in Post-Schooling Education and Training in South Africa. It conducts foundational, directed, and applied research into various aspects of AI through its nine established research groups.

The CAIR's mandate is to develop world-class research capability in South Africa in identified areas of AI and includes establishing a network of AI research chairs and training masters and doctoral students in AI. It also consolidates applied AI research initiatives and supports sustainable and effective socio-economic development by enabling meaningful ethical and informed societal interaction with AI technologies. Moreover, it advises industry, government and NGOs on the use of AI for social and economic advancement. The centre is also expected to contribute to ensuring widespread access to AI technologies and tools in South Africa.

To date, the CAIR has established a range of research groups including the Adaptive and Cognitive Systems Lab, AI and Cybersecurity, AI for Development and Innovation, Deep Learning, and Computational Thinking and AI. Each research groups has one of the centre's partner universities as a focal point. The centre has published a wide range of articles in peer-reviewed journals.



### Potential gaps and tensions

One of the potential tensions that are likely to arise relates to the linkages between research policy and practice – that is, the extent to which CAIR's research findings are applied at scale and the extent to which innovations it produces diffuse to the market and the rest of society.

Another potential tension relates to the research agenda of the centre and the extent to which it is engaging with the most critical issues and challenges such as humane, safe and responsible AI in ways that are relevant to South Africa's citizens.

## Case study 15: Evidence intermediaries: UK EdTech Impact

The rise of evidence intermediaries is another emerging feature in the smart education policy space. The UK's EdTech Impact is an independent review platform that showcases a host of EdTech products from approximately 600 companies including Pearson, Britannica, Discovery Education, Microsoft and Smart Technologies. The EdTech products reviewed on the platform include educational apps on specific subjects like mathematics and English, data-driven adaptive learning solutions and career guidance platforms. The products are categorized by age group and price range – free, freemium, free trials and proprietary options. The platform also provides access to products for low-tech and high-tech environments, thereby catering for a wide range of education stakeholders. The target market is broad: potential investors from the Department of Education, a host of public and private entities, students, parents, teachers and schools.

The establishment of EdTech Impact is consistent with the most recent UK policy on EdTech and is supported by Nesta, an EdTech think tank, the ventures firm Emerge Education, the EdTech incubator Educate, and EdTech UK, a strategic body that accelerates the UK's EdTech sector. It has recently added 'home learning and COVID-19 filters' to enable teachers or parents to find the resources they need to support home learning.



### Potential gaps and tensions

Tensions can arise when a product-oriented EdTech market acts in the commercial interest of companies, and policy needs to respond adequately to such a tension from the perspective of the common public good. In such circumstances, research and development can assume a competitiveness rationale that potentially challenges the equity and inclusion imperatives of the Sustainable Development Goals.

## Summary of the case studies

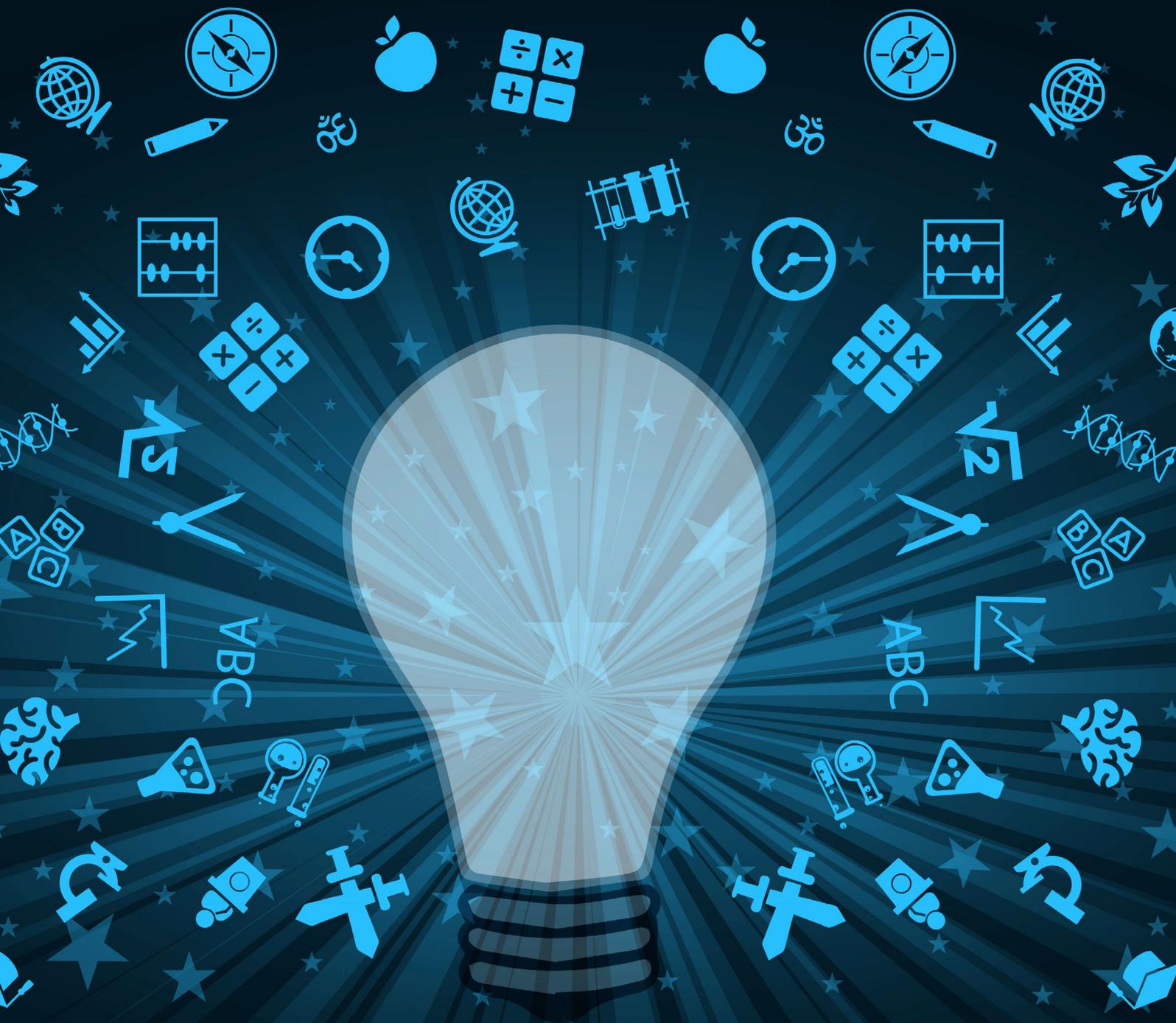
The case study policies on smart education and related case study projects and programmes reveal the exploratory, emergent and complex nature of policy and practice in a volatile and uncertain environment. While there are contextual differences across national systems, there are also similarities in approaches to policy development and the design and implementation of projects and programmes. The case studies reveal evidence of a dominant narrative related to the pressure to grow smart economy and labour market skills and capabilities, and to compete

with major markets in the search for and development of AI talent across the world in the face of a dire shortage of AI skills. The case studies also show attempts at mobilizing the data-driven affordances of smart technologies to address the challenge of school dropout and support learning and assessment. One of the cases shows how curriculum reform can be enacted by integrating AI into an existing curriculum.

The case studies also reveal the heightened attention given to investments in research and development through the establishment of dedicated research institutes. Underpinning the latter are quests to design, develop, implement and manage smart technologies in ways that can confront the threats and dangers they pose for humanity and society. The need to challenge such threats by designing smart technology systems that are more humane, ethical, rights-based, and socially and environmentally just is already manifest in the prevailing policies and practices. It is anticipated that the latter will continue to be an urgent and significant preoccupation among thinkers, policy-makers and researchers as the challenges become increasingly global and complex. Calls for alternatives to systems that perpetuate and exacerbate intersecting inequalities and community-based approaches appear to be surfacing more prominently in global, regional and national conversations, which points to the value of engaging with the issues from a critical perspective, as proposed in this document.

# Chapter 6

## Conclusion



## Conclusion

One of the main objectives of the critical analytical framework for smart education policy outlined in this document was to open up discussion and debate in ways that bring to the surface the complexities, contradictions and tensions that invariably arise in the quest to meet the Sustainable Development Goals. Another objective was to provide insights and guidance to policy-makers who are deliberating over the development of impending smart education public policies.

This framework combines a critical comparative policy discourse analysis with case study methodology when comparing national policies and strategies on ICTE and smart education across ten country case studies of ICTE and smart education policy formation and fifteen related policy-informed implementation projects. It also applies a systematic literature review based on key concepts related to national ICTE and smart education policies and strategies.

The critical analytical framework and its application across the case study policies and implementation projects reveal a host of similarities and convergences in policy and strategy influences, contexts and policy discourses as reflected in policy texts and in policy-informed practices, in the midst of divergent socio-economic, demographic, political and cultural settings.

## Policy and strategy influences

The policies that have evolved over time in all ten countries reveal the influence and pressure of powerful globalizing economic, cultural and political dynamics, underscored by rapid technological change. The existing and projected growth of AI in the global economy and the EdTech market are manifestations of an anticipated escalation of the influence of technological change in global and national systems in general and in education systems in particular.

Moreover, the move towards global dominance and monopolization of AI and related 4IR technological systems by a few companies has also influenced the drive to develop national strategies and plans, as is expressed in the national AI policies of Egypt and Mauritius.

As part of attempts to make sense of the multifaceted changes and associated disruptions, a plethora of global analyses, frameworks and toolkits have been developed by international development agencies to monitor global trends, clarify strategies that are being tried and guide governments and ministries of education on possible strategies. Underpinning many of these toolkits and guidelines, which this framework alludes to across the whole document, are dominant and contending views and insights based on analyses of what is happening and which strategies may be more appropriate from varying points of view. The more recent and emerging smart education-related guidelines and toolkits invite more critical reflections by drawing on ICTE policy experiences and the influence of the COVID-19 pandemic on digital adoption in education.

A salient feature of the more recent deliberations on smart education and policy matters also relates to what can be referred to as a post-digital turn, reflections on the relationship between humans, humanity, nature and technologies in a quest for more humane, equitable, ethical, caring and just transitions.

Alongside global and regional guidelines and frameworks, several countries are developing national and regional AI strategies based on the experiences of leaders in the field, which also reinforces the notion of policy borrowing. As shown in this document, the ten case study countries have particular historical, cultural, political, socio-economic and environmental contexts that influence the way national AI and related policies and strategies in education have been designed. However, the formulation of national strategies has been influenced and often 'benchmarked' against what has been happening in more matured national systems.

## ICTE and smart education policy texts

Across the ten country case studies and fifteen implementation projects, there appear to be strong similarities, suggestive of convergence in dominant socio-technical imaginary and policy discourse related to investments in AI and 4IR technology systems and their integration in national education and training systems.

The problem that many strategies seek to address relates mainly to the scarcity of AI and 4IR skills and capabilities across all the countries that have to date adopted national AI strategies. Building human capacity, skills and an AI- and 4IR-enabled education and training system therefore features prominently in national AI strategies.

The shortage of AI skills and talents and shortage of 4IR research capabilities have become the basis for fierce global competition for the best talent and for mobilizing and building research and development capability. Thus, the skills and competencies, curriculum and pedagogy, education resources and platforms and research themes of the critical analytical framework surfaced more prominently in national AI strategies. The governance theme also surfaced strongly from the perspective of developing robust systems to control and oversee escalating data-intensive 4IR and AI technology systems in education, training and research.

The approach to skills and competencies development includes wide-ranging strategies from raising public awareness about AI and providing courses and programmes for everyone to mobilizing specialized AI skills through attracting talent from around the world. Skills and competency development is tied to the pedagogy and curriculum theme insofar as it promotes the mandatory integration of AI, coding and robotics in varying degrees in both school and university curricula; establishing AI faculties and departments at universities; attracting and incentivizing enrolment in AI-related courses; and developing PhD and master's programmes as part of a strategy to attract, retain and develop AI skills pools in the respective countries.

The research themes across the countries with formally adopted AI strategies include the need to establish dedicated centres of excellence or institutes of research that will seek to attract the best AI brains to promote research into new AI terrain. The latter serves often to grow the local AI industry so that AI-enabled products can be exported to countries worldwide.

Vision statements across all national strategies on AI are primarily aspirational, faith-based statements that range from the aim to become a global leader in AI to growing an AI-enabled economy and industry in ways that will also enable inclusion and social development.

Some of the strategies assumed the form of reports that will lay the basis for more formal adoption, as in South Africa and India. Some provide recommendations for their implementation, including the establishment of oversight and coordination structures such as a national AI council.

In applying the critical analytical framework, tensions, gaps and contradictions were consistently highlighted across each of the six themes in the framework as well as the three implementation mechanisms. The value of discussing areas of tension lies in demonstrating and reflecting on the complexities of the issues so that they are not perceived to be solutionist, linear and technologically deterministic.

There are also some differences across the ten case study countries. Not all pay attention to the need to engage with the negative consequences of AI investments in education and beyond – for example, the challenge of reconciling development questions and issues with globally competitive imperatives. Not all strategies confront the contradictions between rapidly growing AI investment and the impact on the existing climate emergency. The latter is raised only cursorily in the context of an emerging discourse on making a just transition.

The existing strategies have revealed many gaps that will need to be addressed as they evolve and new strategies come into being. Monitoring the progress of the ten countries and their policies and strategies over time and conducting deeper evaluative research will be an important consideration for further work on smart education policy development.

In the context of an emerging post-digital paradigm, more concerted explorations and considerations will likely be given to policies and strategies that can research, design and apply smart educational technologies in human-centred, caring, responsible and ethical ways. Already some ethical frameworks highlight the need for community approaches and greater accountability of AI developers and programmers, states, big tech companies and start-ups. These will be explored in smart education practices across the world.

## Smart education case studies

The fifteen case studies of smart education practices organized by the themes of the critical smart analytical framework provide an overview of the successful implementation of policies in the countries covered. The practice case studies reveal evidence of a dominant narrative related to the pressure to grow smart economy and labour market skills and capabilities, and to compete with major markets in the search for and development of AI talent across the world in the face of a dire shortage of AI skills. The case studies also reveal the heightened attention given to investments in research and development through the establishment of dedicated research institutes and the recruitment of AI researchers from across the globe.

The case studies offer examples of the way AI and related smart technologies are increasingly becoming embedded in the design and delivery of learning, teaching, assessment and education governance and management. Specific cases show the explorative nature of these practices and a realignment of major ecosystem players in the education space. The case studies that highlight learning analytics, pedagogies and assessment also show how these are informed by specific smart technology products that are procured to explore how the design and use of data influence learning, teaching and assessment.

Finally, this document has not only raised a host of critical issues for policy and practice consideration, and for debate and discussion among a growing community of practitioners, policy-makers and technology companies, developers and influencers. It has also revealed important gaps in our collective knowledge and the need for a critical research agenda that is focused on meeting the seventeen Sustainable Development Goals. A smart education policy template and a monitoring and evaluation framework based on the Sustainable Development Goals are therefore proposed.

## Smart education policy development – a template

The critical framework used in the study asked questions and identified issues for consideration as country governments, ministries of education and their partners wrestle with the complexity of the challenges that accompany rapid technological change combined with the volatility of social upheaval, pandemics and a growing climate emergency. It also highlighted possible tensions and gaps, some of which have already become evident, pointing to the need for ongoing research and critical engagement to address risks and threats to the ethics and principles of safety and security, inclusion and equity espoused in the Sustainable Development Goals.

Table 15 provides a broad framework that can be used as a template for consideration in the development of smart education policy text. The framework does not go into detail about the process of policy development and focuses largely on substantive considerations in policy text. It highlights thematic areas, key issues for consideration in each thematic area and key questions to consider. It therefore serves as a basis to frame and guide the policy conversation among policy-makers and their partners.

**Table 15. A basic framework for monitoring ICTE and smart education policy implementation**

Policy themes	Guiding questions
<b>Policy context</b>	<p>Which ICTE/smart education initiatives have been tried before and what are the key lessons?</p> <p>How can policy design be responsive to the cultural, social and linguistic contexts of the stakeholders at whom the policy is aimed?</p> <p>What socio-economic and political factors will influence the design of the policy?</p>
<b>Policy rationale</b>	<p>What is the rationale for the policy, or revised and updated policy, on ICTE/smart education?</p> <p>Are there contending rationales on ICTE or smart education that the policy should consider?</p>
<b>Problem-responsive policy</b>	<p>What systemic learning, teaching skills development and talent management challenges do the policy and strategy seek to address?</p> <p>What are the causes of these challenges?</p> <p>What are the likely tensions that could emerge in terms of the most critical education and training system challenges the policy would need to address?</p>
<b>Policy vision, values and principles</b>	<p>What is the vision that the policy aims to realize? By when?</p> <p>Is this a shared vision of the various stakeholders involved?</p> <p>How does the ICTE/smart education policy vision align with the national country and global development goals?</p> <p>What are the key principles that will guide the ICTE/smart education policy?</p> <p>Are there possible tensions related to a shared vision, values and principles to which the policy would need to respond?</p>
<b>Policy goals and intended outcomes</b>	<p>What are the goals of the policy? What are the intended ICTE/smart education policy outcomes? How do the goals and outcomes align with national government and global development goals? Do the goals and outcomes consider possible ways in which they may not be met? How can these risks be mitigated?</p> <p>What tensions could possibly arise with the articulation of policy goals and outcomes?</p> <p>Are the goals and outcomes specific, measurable, achievable, realistic and time-bound?</p>
<b>Policy theme 1: Infrastructure</b>	<p>What is the nature of the problem that the technology infrastructure seeks to address?</p> <p>What are the lessons learned from previous educational technology infrastructure roll-out attempts?</p> <p>What existing related policies, laws and regulations govern educational technology infrastructure access?</p> <p>What are the educational technology infrastructure access goals?</p> <p>How will policy prescribe access to technology infrastructure in safe, equitable, meaningful and universal ways?</p> <p>Who are the right stakeholders to engage with and lead infrastructure access?</p> <p>How will the environment be protected with the roll-out, use and disposal of technology infrastructure?</p> <p>How will policy engage with and manage technological change?</p> <p>What technology infrastructure tensions and gaps are anticipated and need to be managed?</p>

<p><b>Policy theme 2: Curriculum, pedagogy and assessment</b></p>	<p>What is the nature of the learning, teaching, assessment and curriculum challenges that the ICTE/smart education policy is addressing?</p> <p>What existing related policies, laws and regulations govern educational technology infrastructure access?</p> <p>What lessons can be learned from the previous evolution of curriculum reform on technology-enabled learning and teaching, skills development and creative enquiry?</p> <p>What is the appropriate curriculum and pedagogical approach to the integration of digital and exponential technologies in learning, teaching and skills development?</p> <p>How will the required curriculum and pedagogical changes be enacted?</p> <p>Should new ICTE/smart education subjects be introduced? If so, which subjects should be prioritized? How will they be introduced and managed?</p> <p>What possible curriculum, pedagogical and assessment tensions may arise to which policy needs to respond?</p>
<p><b>Policy theme 3: Digital education resources and platforms</b></p>	<p>What is the nature of the problem that the policy will be addressing in terms of digital education resources and platforms?</p> <p>What lessons can be learned from previous policies on digital education resources and platforms?</p> <p>What existing related policies, laws and regulations govern educational technology infrastructure access?</p> <p>What is the policy's approach to ensuring equitable and widespread access to educational resources for learning, teaching, skills development and creative enquiry? Should open educational resources and open education practices be prescribed in the policy?</p> <p>What approach should the policy adopt on education platforms?</p> <p>What policy tensions may arise in relation to digital education resources and platforms?</p>
<p><b>Policy theme 4: Skills and competencies</b></p>	<p>What is the nature of the problem that the policy will be addressing in relation to skills and competencies for smart education and ICTE?</p> <p>What lessons can be learned from previous policies on skills and competencies for ICTE and smart education?</p> <p>What existing related policies, laws and regulations govern educational technology infrastructure access?</p> <p>How can the policy respond to growing the required skills, competencies and agency of students, teachers and managers?</p> <p>How can the policy respond to the recognition of skills and microcredentialing requirements?</p> <p>What are the policy tensions and gaps that are likely to emerge in the policy attempts at growing the requisite skills, competencies and agency of relevant stakeholders in the education and training system?</p>
<p><b>Policy theme 5: Governance</b></p>	<p>How can the policy ensure safe, ethical secure governance of ICTE/smart education reforms?</p> <p>How will the policy ensure responsible digital citizenship, digital well-being and responsible machine learning principles?</p> <p>What are the possible policy tensions and gaps that may arise in relation to the governance of ICTE/smart education?</p>
<p><b>Policy theme 6: EMIS</b></p>	<p>How will the policy respond to big data in education management and information systems?</p> <p>What are the possible policy tensions relating to EMIS that policy will need to manage?</p>

## Policy implementation monitoring frameworks

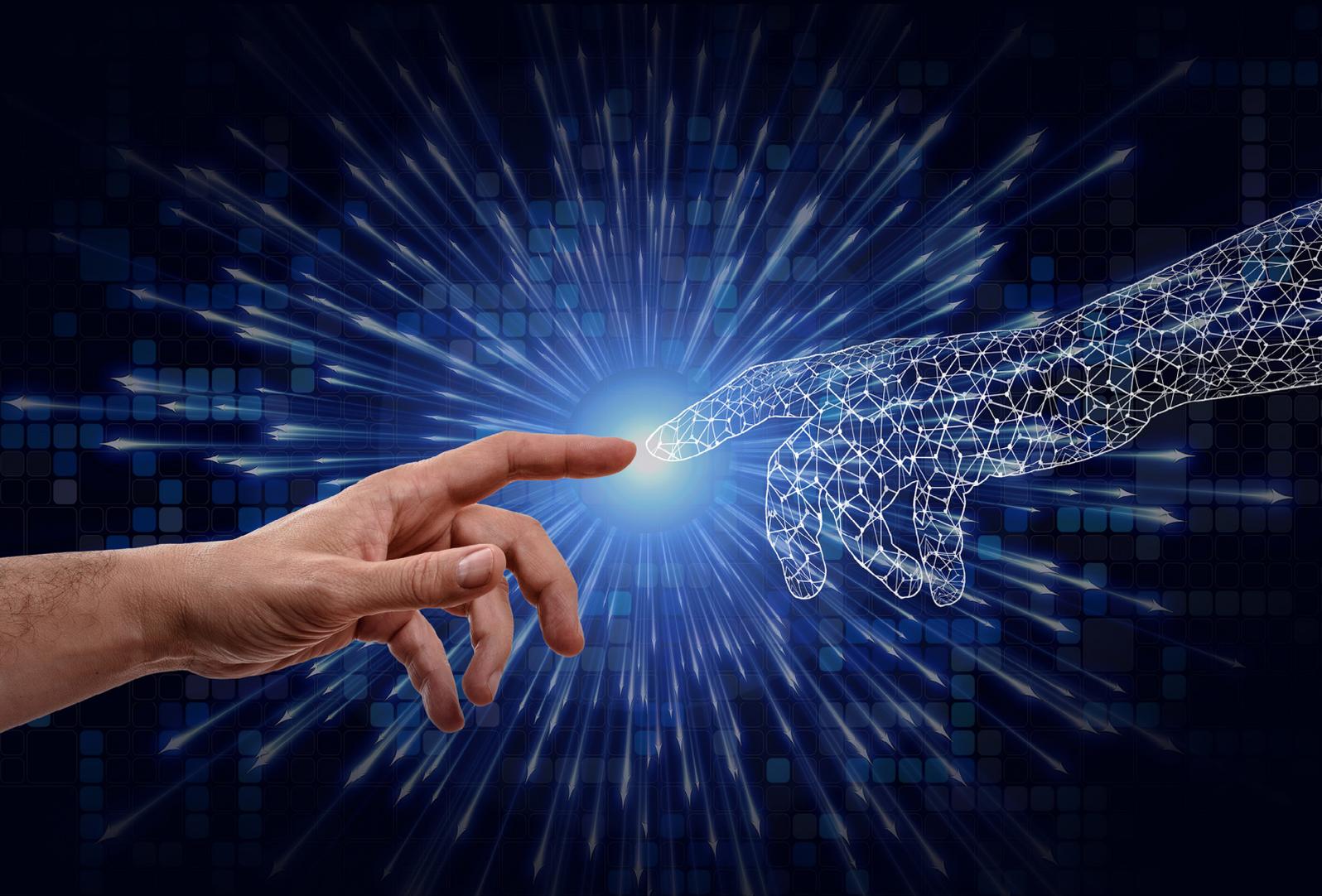
To answer the overarching question posed by this critical framework on smart education policy – how have policies been designed, implemented, and evaluated? – and in recognition that limited attention has been paid to supporting governments with ICTE policy implementation, Table 16 provides a basic framework for monitoring, assessing and guiding ICTE and smart education national policy implementation. This framework recognizes the fact that national contextual factors strongly influence policy implementation, and that policy implementation is a complex process which limits comparability within and between countries.

**Table 16. A basic framework for monitoring ICTE and smart education policy implementation**

	Guiding questions	Latent	Emerging	Well-developed
<b>Implementation masterplan</b>	Has a process been established to develop a plan to implement a national ICTE/smart education policy?	The intention to develop a plan is stated in policy but plans to enact the policy intent are not clear	Policy intention to establish an implementation plan is stated A system and process are proposed, and a plan that involves many stakeholders is developed	Policies have been accompanied by detailed implementation plans involving relevant stakeholders with each successive iteration of the plan over time, and have enabled evidence
<b>System capacity</b>	Has the education system invested in the required capabilities, skills and resources to implement the ICTE/smart education policy?	The intention to develop a plan for system capacity-development is stated in policy but there are no plans in place to develop and implement the plan	Policy intention to establish an implementation plan is stated A system and process are proposed, and a plan that involves many stakeholders is developed	System-strengthening processes and systems have been tested, developed and implemented over time to develop capacity of the national system at institutional and national levels with positive evidence-based outcomes
<b>Leadership development</b>	Has a dedicated leadership structure been established at national and institutional levels? Is there a process in place to ensure continuous leadership development?	The intention to develop leadership capability is stated in the policy but the enactment of the policy intent is not clear	Policy intention to establish an implementation plan is stated A system and process are proposed and a plan that involves many stakeholders is developed	Leadership development systems and processes have been implemented over time and have improved continuously to produce positive evidence-based education improvement outcomes
<b>Change management processes and systems</b>	Has a change process been discussed and shared among stakeholders? Is there a shared system in place to lead and manage change catalysed by ICTE adoption over time at various levels across the national system?	The intention to develop a change management plan is stated in policy but the enactment of the policy intent is not clear	Policy intention to establish an implementation plan is stated A system and process is proposed and a plan that involves many stakeholders is developed	Change management systems and processes have been tested over time and have been improved continuously to enable positive evidence-based education improvement outcomes

<b>Partnership development and management</b>	Is there a partnership development plan in place? How are multiple partner relationships managed over time?	The intention to develop a plan to develop and manage partners is stated in policy but the enactment of the policy intent is not clear	Policy intention to establish an implementation plan is stated  A system and process is proposed and a plan that involves many stakeholders is developed	Processes and systems have been established and are continuously improving to develop and manage partners at all levels of the system with positive evidence-based outcomes
<b>Finance and funding models</b>	Have dedicated realistic budgets been developed for ICTE investments across the national education system? Are clear financing mechanisms in place? Are clear systems in place to manage budget spend? Are fair procurement management systems in place?	The intention to develop a plan to finance ICTE and smart education is stated in policy, but the enactment of the policy intent is not clear	Policy intention to establish an implementation plan is stated  A system and process is proposed and a plan that involves many stakeholders is developed	Cost-effective and cost-efficient innovative ICTE and smart education financing and funding models have evolved over time and with positive evidence-based educational outcomes
<b>Resource mobilization</b>	Have dedicated realistic budgets been developed for ICTE investments across the national education system? Are clear financing mechanisms in place? Are clear systems in place to manage budget spend? Are fair procurement management systems in place?	The intention to mobilize resources for ICTE and smart education is stated in policy but the enactment of the policy intent is not clear	Policy intention to establish an implementation plan is stated  A system and process are proposed, and a plan that involves many stakeholders is developed	Systems for effective and efficient resource mobilization that optimally resources investments in ICTE and smart education have led to evidence-based education outcomes
<b>Research and innovation</b>	Have dedicated realistic budgets been developed for ICTE investments across the national education system? Are clear financing mechanisms in place? Are clear systems in place to manage budget spend? Are fair procurement management systems in place?	The intention to develop a plan is stated in policy but the plan to enact the policy intent is not in place	Policy intention to establish an implementation plan is stated  A system and process is proposed and a plan that involves many stakeholders is developed	Inclusive research and innovation in ICTE and smart education systems have developed over time with positive educational benefits to and outcomes for the national education and training system
<b>Monitoring and evaluation</b>	Has a theory of change been developed? If so, is it accompanied by an operational theory of change and logical framework?  Has a monitoring evaluation and learning framework been developed?  Is an M&E implementation plan in place with clearly established milestones for reporting and implementing lessons?	The intention to integrate M&E in ICTE national plans is stated in policy but the enactment of the policy intent is not clear	Policy intention to establish an implementation plan is stated  A system and process are proposed, and a plan that involves many stakeholders is developed	Monitoring, evaluation and learning systems are established and continuously serve to improve ICTE and smart education design and implementation with continuous positive educational outcomes

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# Smart Education Strategies for Teaching and Learning:

## Critical analytical framework and case studies

This electronic publication about smart education strategies for building the resilience of education and training systems in the post-pandemic environment provides a framework to develop appropriate policy and strategy in existing and emerging forms of schooling, higher education, technical and vocational education, and training (TVET), adult education and lifelong learning, including formal, non-formal and informal educational environments. While the discussion takes a historical view, it is also forward-looking and future-oriented. It hopes to contribute to ongoing, evolving conversations and debates on appropriate smart education policy development.

The publication reviews the status of smart education policies in 10 countries. It includes 15 case studies within the six policy themes: infrastructure, curriculum and pedagogy, digital education resources and platforms, skills and competencies, governance, management and administration, and partnership. A policy template and a mechanism for monitoring and evaluating smart education policy implementation included in the publication would help the UNESCO Member States adopt smart education policies and strategies.