unesco

AI
HERE, THERE
AND EVERYWHERE

State of the Education Report for India 2022
Artificial Intelligence in Education

UNESCO Education Sector
Education is UNESCO's top priority because it is a basic human right and the foundation on which to build peace and drive sustainable development. UNESCO is the United Nations' specialized agency for education and provides global and regional leadership in education, strengthens national education systems and responds to contemporary global challenges through education, with a special focus on gender equality and Africa.

The Global Education 2030 Agenda
As the United Nations' specialized agency for education, UNESCO is entrusted to lead and coordinate the Education 2030 Agenda – part of a global movement to eradicate poverty through 17 Sustainable Development Goals by 2030. Education, essential to achieving all of these goals, has its own dedicated Goal 4, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. The Education 2030 Framework for Action provides a guideline for implementing this ambitious plan.

HERE, THERE AND EVERYWHERE
AI IN EDUCATION
State of the Education Report for India 2022

Please email newdelhi@unesco.org for prior permission to use any material not clearly identified as belonging to UNESCO.

The designations employed and the presentation of material throughout this publication do not imply the expression of any opinion whatsoever on the part of UNESCO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The ideas and opinions expressed in this publication belong solely to the authors and UNESCO does not necessarily commit and subscribe to the same.

AI

HERE, THERE AND EVERYWHERE

State of the Education
Report for India 2022
**Artificial Intelligence
in Education**

unesco

Student works on an AI-based program to recognize faces.
Modern Public School, Delhi, India.

Foreword

> "
> We believe that we should neither be fearful of, nor blindly embrace the application of Artificial Intelligence in education.
> "

It is still early days when it comes to our interaction with Artificial Intelligence and how machines and computer systems can complement human intelligence. In the specific case of Artificial Intelligence applied to the field of education, the body of research and recommendations is somewhat limited and the issue needs to be better explored – in India and elsewhere.

This is why we decided to devote this fourth edition of the UNESCO State of the Education Report for India to this important topic, all the more so given that the Government of India's public policy think tank, NITI Aayog, has recognized the significance of AI literacy and has considered it a national priority since 2018. India's National Education Policy of 2020, which prioritizes the integration of Artificial Intelligence in education, keenly reflects this importance as well.

The United Nations' Sustainable Development Goal 4 calls for improvements in the quality of education and the learning outcomes of all students, which cannot be achieved without significant innovation. India itself has made considerable strides in its education system and strong indicators point to the country's notable efforts to enhance learning efficiency, including by using Artificial Intelligence-powered technology.

During the Coronavirus (COVID-19) pandemic, the key role that technology played in mitigating learning losses was also clear testimony to how dependent the world has become on technology. The hope is that, in the coming years, Artificial Intelligence will play a positive and pivotal role in India's continuously evolving education sector.

At the same time, while acknowledging the growing presence of Artificial Intelligence in everyday life, it is crucial to uphold the fundamental principles of ethics regarding Artificial Intelligence. For UNESCO, all discussions relating to AI in Education need to revolve around the values and human dimensions of Artificial Intelligence and its purpose to serve the common good.

As UNESCO's 2021 *Recommendation on the Ethics of Artificial Intelligence* made clear, AI has indeed the potential to radically reduce inequalities, promote diversity and benefit humanity as a whole, provided national and international policies as well as regulatory frameworks ensure that human-centred technologies benefit the greater interest of the people, and not the other way around.

With this State of the Education Report focusing on Artificial Intelligence in Education, UNESCO wants to offer a glimpse of the varied dimensions and challenges regarding the current and future use of Artificial Intelligence in the Indian educational setting. We hope this publication will serve as a useful reference tool for enhancing and influencing programmes and policies.

All in all, and based on the many creative examples and case studies highlighted in this report, we believe that we should neither be fearful of, nor blindly embrace the application of Artificial Intelligence in education. As suggested by the title of this report, Artificial Intelligence is already very present in the Indian education system and it is here to stay. The question, therefore, is how to best manage this technological evolution for and with younger generations.

I wish to extend my sincere thanks and appreciation to the many people who contributed to this report and acknowledge the support of Intel India and Vantage. Our UNESCO New Delhi team also looks forward to continuing our collaboration with fellow-minded institutions for the 2023 edition of the report, which is expected to focus on Education for Sustainable Development.

Eric Falt
Director,
UNESCO New Delhi

intel® digital readiness

Intel's purpose is to 'create technology that improves the life of every person on the planet.' Making technology inclusive and expanding digital readiness is a key component of Intel's goals and critical to the company's corporate purpose.

Increased digitalization requires investments in building the digital capacities of people, specifically in emerging technologies like Artificial Intelligence (AI). Digital Readiness encompasses skills, trust and responsible use of technology for broader socio-economic benefits. The Intel® Digital

Readiness Program Portfolio was rolled out globally in collaboration with governments, academia, civil society and industry partners and has expanded to 27 countries and impacted over 3 million people to date.

Intel is committed to collaborating with 30 countries' governments, enabling digital access to 30 thousand institutions and skilling 30 million people for current and future jobs.

Intel® Digital Readiness Programs in India

In India, the shared value and shared responsibility programs aim to demystify and democratize AI for broader diverse and non-technical audiences, irrespective of their location, gender and ethnicity. The program portfolio consists of 5 key programs:

AI FOR ALL based on Intel® AI for Citizens	**AI INTEGRATION IN SCHOOL CURRICULUM** based on Intel® AI for Youth	**RESPONSIBLE AI FOR YOUTH** based on Intel® AI for Youth	**BUILDING AI READINESS AMONG YOUNG INNOVATORS** based on Intel® AI for Youth	**DIGITAL INDIA DIALOGUES** based on Intel® Digital Readiness for Leaders
in collaboration with the Ministry of Education, Government of India	in collaboration with the Central Board of Secondary Education	in collaboration with the Ministry of Electronics & IT, Government of India	in collaboration with the Department of Science & Technology, Government of India	in collaboration with the Ministry of Electronics & IT, Government of India
Aimed to reach **1** million users in one year (July 2021-22)	Skilled **350,000+** students	Skilled **52,000+** students	Skilled **10,000+** students	Enabled **3,260+** government officials
Achieved **2** million users till July, 2022	Impacted **10,000+** schools	Empowered **100+** AI solutions	Empowered **1,500+** AI solutions	Impacted **39** government departments
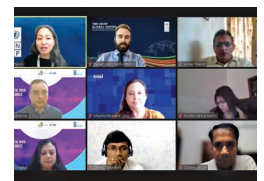
Table of contents

Acknowledgements

Authors and editorial board members

Abbreviations and acronyms

AES	Automated Essay Scoring		HEI	Higher Education Institution
AI	Artificial Intelligence		IAMAI	Internet and Mobile Association of India
AIED	Artificial Intelligence in Education		ICT	Information and Communications Technology
AIM	Atal Innovation Mission		IDB	Inter-American Development Bank
AISC	AI Student Community		IIIT	International Institute of Information Technology
ALS	Amyotrophic Lateral Sclerosis			
API	Application Programming Interface		IISc	Indian Institute of Science
AR	Augmented Reality		IIT	Indian Institute of Technology
ASER	Annual Status of Education Report		ILO	International Labour Organization
ATL	Atal Tinkering Lab		IoT	Internet of Things
B.A.	Bachelor of Arts		IRCAI	International Research Institute on Artificial Intelligence
B.C.A.	Bachelor of Computer Applications		ISB	Indian School of Business
B.E.	Bachelor of Engineering		IT	Information Technology
B.Sc.	Bachelor of Science		ITS	Intelligent Tutoring System
B.Tech.	Bachelor of Technology		KGBV	Kasturba Gandhi Balika Vidyalaya
CAGR	Compound Annual Growth Rate		M.B.A.	Master of Business Administration
CBSE	Central Board of Secondary Education		M.C.A.	Master of Computer Applications
CCC	Command and Control Centre		MFD	Multi-Function Display
CIET	Central Institute of Educational Technology		M.Sc.	Master of Science
			M.Tech.	Master of Technology
CoBot	Collaborative Robot		MeitY	Ministry of Electronics and Information Technology
CT	Computational Thinking			
DEF	Digital Empowerment Foundation		MINE	Microsoft Intelligent Network for Eyecare
DIKSHA	Digital Infrastructure for Knowledge Sharing		MIT	Massachusetts Institute of Technology
DRDO	Defence Research and Development Organisation		ML	Machine Learning
			MoE	Ministry of Education
DST	Department of Science and Technology		MoU	Memorandum of Understanding
			NATS	National Apprenticeship Training Scheme
EdTech	Education Technology			
Ei	Educational Initiatives		NCE	National Coalition for Education
ELTI	Ethical Leadership in Tinkering and Innovation		NCERT	National Council of Educational Research and Training
FAIR	Findable, Accessible, Interoperable or Reusable		NDEAR	National Digital Education Architecture
GDP	Gross Domestic Product			
GPT-3	Generative Pre-trained Transformer-3		NEP	National Education Policy
GVD	Graphic and Virtual Design			

Above: Lab dedicated to Artificial Intelligence, Dr Rajendra Prasad Kendriya Vidyalaya, New Delhi, India.

NGO	Non-Governmental Organization		SIE	State Institute of Education
NIPUN Bharat	National Initiative for Proficiency in Reading with Understanding and Numeracy		SMS	Short Messaging Service
			SoE	State of the Education
NIRAMAI	Non-Invasive Risk Assessment with Machine Intelligence		SoER	State of the Education Report
			SSMI	Severe Speech and Motor Impairment
NISHTHA	National Initiative for School Heads' and Teachers' Holistic Advancement		ST	Scheduled Tribe
NITI Aayog	National Institution for Transforming India		STEAM	Science, Technology, Engineering, the Arts and Mathematics
NLP	Natural Language Processing		STEM	Science, Technology, Engineering and Mathematics
NRF	National Research Foundation		UDISE	Unified District Information System for Education
OECD	Organisation for Economic Co-operation and Development		UDISE+	Unified District Information System for Education Plus
OGD	Open Government Data		UK	United Kingdom
P.G.D.G.A.	Postgraduate Diploma in Graphics and Animation		UNESCO	United Nations Educational, Scientific and Cultural Organization
P.G.D.M.	Postgraduate Diploma in Management		UNICEF	United Nations International Children's Emergency Fund
Ph.D.	Doctor of Philosophy		USA	United States of America
PTR	Pupil-Teacher Ratio		UT	Union Territory
ROAM	Rights, Openness, Accessibility to all and Multistakeholder participation		VIT	Vellore Institute of Technology
			VR	Virtual Reality
SC	Scheduled Caste		VSK	Vidya Samiksha Kendra
SCERT	State Council of Educational Research and Training		WEIRD	Western, Educated, Industrialized, Rich and Democratic
SDG	Sustainable Development Goal			

Executive summary

One of the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development, SDG 4 aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. While Artificial Intelligence (AI) is not specifically mentioned in the 2030 Agenda, UNESCO and many other stakeholders have acknowledged that AI and AI-powered solutions have the potential to act as enablers towards many SDGs, including SDG 4. This carries positive implications for India in particular, where the responsible and human-centred application of suitable AI systems through system-wide policy adjustments and in-depth engagement with all stakeholders could not only lead to long-desired equality, equity and inclusion in education, but also to improved learning outcomes.

About the report

The aim of this report and its recommendations is to advocate for and provide guidance towards the responsible and human-centred application of Artificial Intelligence in Education (AI in Education) in India by outlining its opportunities and challenges, and to offer advice to harness the former and to tackle the latter. First, this report provides an introduction to AI, to demystify a subject that has endured various misconceptions. This is supplemented by an overview of challenges in the Indian education sector that AI may alleviate. Thereafter, this report presents a thorough description of the theoretical background of all aspects of AI in Education, illustrated by a variety of case studies from India. A dedicated chapter explores the related subject of AI literacy in India and AI as a subject in the country's curricula. This report concludes with ten key recommendations.

Below: A young learner experiencing augmented reality in his classroom. Modern Public School, Delhi, India.

AI-powered solutions have the potential to act as enablers towards many SDGs, including SDG 4.

Key findings

AI LITERACY IN INDIA

AI literacy is becoming highly relevant in India since the AI market is the primary growth driver of the broader information technology (IT) and data science industry (see, for example, Analytics India Magazine and Jigsaw Academy, 2020). Jobs in these fields require AI literacy, which applies to newcomers in the industry as well as to experienced staff requiring retraining to keep up with rapid developments in AI.

As early as 2018, the public policy think tank of the Government of India, NITI Aayog acknowledged the importance of AI literacy in India and saw it as a national priority. This recognition is also reflected in the National Education Policy of 2020, which emphasizes the integration of AI in education (Ministry of Education, 2020a). AI literacy consists of a technological and a human dimension; the technological dimension is concerned with data and algorithm literacy, while the human dimension comprises building awareness about the limitations and risks of AI and debating the various aspects of AI ethics. The latter dimension is often neglected, although it is relevant to all individuals who manage or work with AI, which is likely to be everyone in the future. Compared to other countries, India is well advanced in terms of AI literacy, which is illustrated, for example, by the fact that India has the highest relative AI skill penetration rate worldwide (Zhang et al., 2022). However, two issues require attention: women and girls and other disadvantaged socio-economic groups often have fewer opportunities to become AI literate in India, and the human dimension of AI literacy is often overlooked compared with its technological dimension.

> AI literacy consists of a technological and a human dimension; the technological dimension is concerned with data and algorithm literacy, while the human dimension comprises raising awareness about the limitations and risks of AI.

Within the category of AI-powered education tools, this report focuses on comprehensive and personalized intelligent tutoring systems (ITS) and how these could bring about equality, equity, inclusion and improved learning outcomes.

Since AI is a dual-use technology, it also entails challenges and risks, some of which concern AI in general, while some are specific to AI in Education and others are specific to India alone.

OPPORTUNITIES FOR INDIA

AI-powered education tools offer opportunities across various aspects of education, which are categorized here as formal and informal learning, teaching, evaluation, school management, as well as mapping and matching of skills. The focus of this report is on the category of learning with special attention on comprehensive and personalized intelligent tutoring systems (ITS) and how these could bring about equality, equity, inclusion and improved learning outcomes. A long-standing flaw of today's education system is that it applies a one-size-fits-all approach. An intelligent tutoring system addresses this issue by tracking the learning outcomes and assessing the competencies of individual students in real time. Based on this, the intelligent tutoring system discovers patterns and trends indicating individual strengths, weaknesses, levels of knowledge and speed of learning, and develops predictive analytics and a customized curriculum for each student within a framework of nationally determined macro concepts. The learning material of the customized curriculum is accessible online at any time. Intelligent tutoring systems also support differently abled students, linguistic minorities and other marginalized groups according to their needs. Teachers are empowered by intelligent tutoring systems and by additional AI-powered tools for administration, teaching and evaluation. Moreover, AI-powered tools support school management and enable the mapping and matching of skills for the labour market. All these different tools are illustrated throughout this report with case studies from India.

CHALLENGES FOR INDIA

Since AI is a dual-use technology, it also entails challenges and risks, some of which concern AI in general, while some are specific to AI in Education and others are specific to India alone. Globally, the drafting of required AI-related policies is not only lagging behind the rapid technological developments in the field, but it is also an open question whether and to what extent AI systems can be governed at all, given that they are more advanced than humans and thus often act in what are, to humans, unexplainable, non-transparent and opaque ways.

Another broad and crucial field is the Ethics of AI, of which the two aspects, of data privacy and ownership, as well as algorithmic fairness and biases, are particularly relevant for AI in Education as the data of AI in Education systems are often owned by private companies, which can lead to undesirable consequences. Also, Sambasivan et al. (2021) have highlighted several 'axes of

potential Machine Learning (un)fairness in India' (prevalent in many societies including India), such as gender, religion, ability, class, gender identity, sexual orientation and ethnicity, all of which may contribute to bias in AI in Education systems. A remedy against bias and discrimination would be appropriate training data. However, shortage of training data for Artificial Intelligence in Education Systems is another challenge in India. This data should be contexualized and reflect Indian reality, and should not, therefore, be substituted by externally sourced data. Further challenges mentioned in this report are linked to increasing AI-based fakes and forgeries, including a range of AI-supported tools for students to cheat with; the changing role of teachers; and issues related to resources and infrastructure, which are particularly important in India's case. This is of even more consequence as suitable resources and infrastructure are indispensable preconditions for overcoming inequality and the digital divide through AI in Education systems.

CONCLUSION

A variety of AI-powered education tools offer opportunities across many aspects of education such as formal and informal learning, teaching, evaluation, school management, as well as mapping and matching of skills. One such solution is that of personalized intelligent tutoring systems within the category of formal learning, which can be considered the centrepiece of these tools.

Intelligent tutoring systems could prevail in India if the necessary opportunities are harnessed and the existing challenges are addressed. This could lead to a positive disruption of the Indian education system, as envisioned in this State of the Education (SoE) report as follows:

- Responsible and human-centred application of AI in the Indian education sector has progressed significantly by 2030.

- AI in Education systems have contributed considerably to the achievement of SDG 4 in India, resulting in unprecedented equality, equity and inclusion in education.

- Personalized intelligent tutoring systems have also led to improved learning outcomes by replacing the obstructive one-size-fits-all approach with individually optimized curricula based on a deluge of data and AI-powered detection of patterns and trends that are beyond the capabilities of human teachers to process.

However, in order for this vision to become a reality, a range of challenges and risks related to AI use and management would have to be addressed first, both at the global level and at the national level in India.

Opposite page: Autonomous robotics research at the International Institute of Information Technology, Bengaluru, Karnataka, India.

The way forward

The following ten recommendations describe actions to tackle these challenges and risks:

RECOMMENDATION 1

Consider the Ethics of Artificial Intelligence in Education as an utmost priority.

RECOMMENDATION 2

Rapidly provide an overall regulatory framework for Artificial Intelligence in Education.

RECOMMENDATION 3

Create effective public-private partnerships.

RECOMMENDATION 4

Ensure that all students and teachers have access to the latest technology.

Above: Students taking part in an Artificial Intelligence skills session in an AI Skills Lab. Dr Rajendra Prasad Kendriya Vidyalaya, New Delhi, India.

RECOMMENDATION 5

Expand AI literacy efforts.

RECOMMENDATION 6

Attempt to correct algorithmic biases and the resulting discrimination.

RECOMMENDATION 7

Improve public trust in Artificial Intelligence.

RECOMMENDATION 8

Request the private sector to better involve students and educationists in developing AI products.

RECOMMENDATION 9

Place ownership of data with the students.

RECOMMENDATION 10

Embrace the versatility of Artificial Intelligence in Education systems.

About the report

This chapter offers a brief introduction to the context of this report, as well as its purpose, aim, scope, methodology and structure.

Left: Student testing a gesture-controlled robot. Indian Institute of Science, Bengaluru, Karnataka, India.

1 About the report

In 2019, as part of its mandate to support South Asian Member States in the development of robust, evidence-driven policies in the field of education, the UNESCO Office in New Delhi launched a series of annual State of the Education (SoE) reports for India, each focusing on a particular theme.

The first SoE report highlighted accomplishments and challenges regarding the right to education of children with disabilities and was titled *N for Nose*. The second report was called *Vocational Education First* and focused on the skills development ecosystem, with an emphasis on policy recommendations and best practices for enhancing access, lifelong learning and digitalization, amongst other aspects of vocational education. The 2021 SoE report, titled *No Teacher, No Class*, investigated various aspects of teacher support, preparation and motivation, while also examining the impact of the COVID-19 pandemic on teachers in India.

For this fourth edition of the SoE report for India, UNESCO New Delhi has identified Artificial Intelligence (AI) in Education as its theme. The selection of this theme is timely due to the recent and rapid development of AI and its impact on many fields, including education at various levels, in which AI applications are becoming increasingly common in India.

Below: Student using an AI-powered personalized online learning platform to study. Hebbagodi Government School, Bengaluru, Karnataka, India.

> AI has the potential to address some of the biggest challenges in education today, innovate teaching and learning practices, and ultimately accelerate the progress towards SDG 4. However, these rapid technological developments inevitably bring multiple risks and challenges, which have so far outpaced policy debates and regulatory frameworks. (UNESCO, 2021e, p. 1).

The UNESCO publication
AI and education: Guidance for policy-makers

The theme of this 2022 report is not only more futuristic than previous ones, but also more contentious, as is often the case when new and emerging technologies are being developed and their full impact has not yet been fully assessed due to limited knowledge and evidence. Consequently, alongside a detailed chapter on opportunities for AI in Education in India, this SoE report contains a chapter that comprehensively outlines the risks and challenges posed by AI, as referred to in the quotation above, that require urgent attention.

The required capabilities and subdisciplines of AI include natural language processing (NLP), knowledge representation, automated reasoning, machine learning, computer vision and robotics.

Above: A teacher explains various aspects of Artificial Intelligence to her students. Delhi Public School Bangalore East, Bengaluru, Karnataka, India.

Purpose, aim and scope

The responsible and human-centred application of AI has the potential to alter the education system in India considerably. If steered in the right direction, this could lead to long-desired equality, equity and inclusion in education in India, accompanied by improved learning outcomes and significant advances towards SDG 4. The purpose and aim of this SoE report and its recommendations is to guide this undertaking.

Artificial Intelligence is not easy to define. On the one hand, AI is just a technical concept and not something that really exists, in contrast to machine learning (ML) algorithms, which are specific AI tools that have been developed with increasing success in recent years. On the other hand, a definition of AI is challenging because the definition of intelligence itself is not straightforward. Legg and Hutter (2007, p. 12) offer the following general definition: 'Intelligence measures an agent's ability to achieve goals in a wide range of environments'. Using this definition, intelligence would be considered regular intelligence were the 'agent' a human, and as artificial intelligence were the 'agent' a machine. This is the definition of AI used for the purposes of this report, which encompass the following required capabilities

and subdisciplines of AI as outlined by Russell and Norvig (2020): natural language processing (NLP), knowledge representation, automated reasoning, machine learning, computer vision and robotics.

There are various misconceptions and myths about AI, partly caused by inappropriate portrayals in the media and in fiction, which may confuse, deter or intimidate people. Utmost attention should be paid to ensure clarity and understanding, particularly when it comes to applying AI in the field of education. As such, this report also aims to demystify AI since the opportunities of AI in education can only prevail if all stakeholders, including students, teachers and parents, trust the systems.

When it comes to AI in education, an important distinction must be made between AI literacy and AI-powered educational technology. AI literacy denotes Artificial Intelligence as a subject in the curriculum, and a dedicated chapter in this report elaborates on why this subject is important in India and to what extent students in India master it. Educational technology refers to the application of technologies to facilitate and improve learning. If such technology is supported by AI tools, it is referred to as AI-powered educational technology.
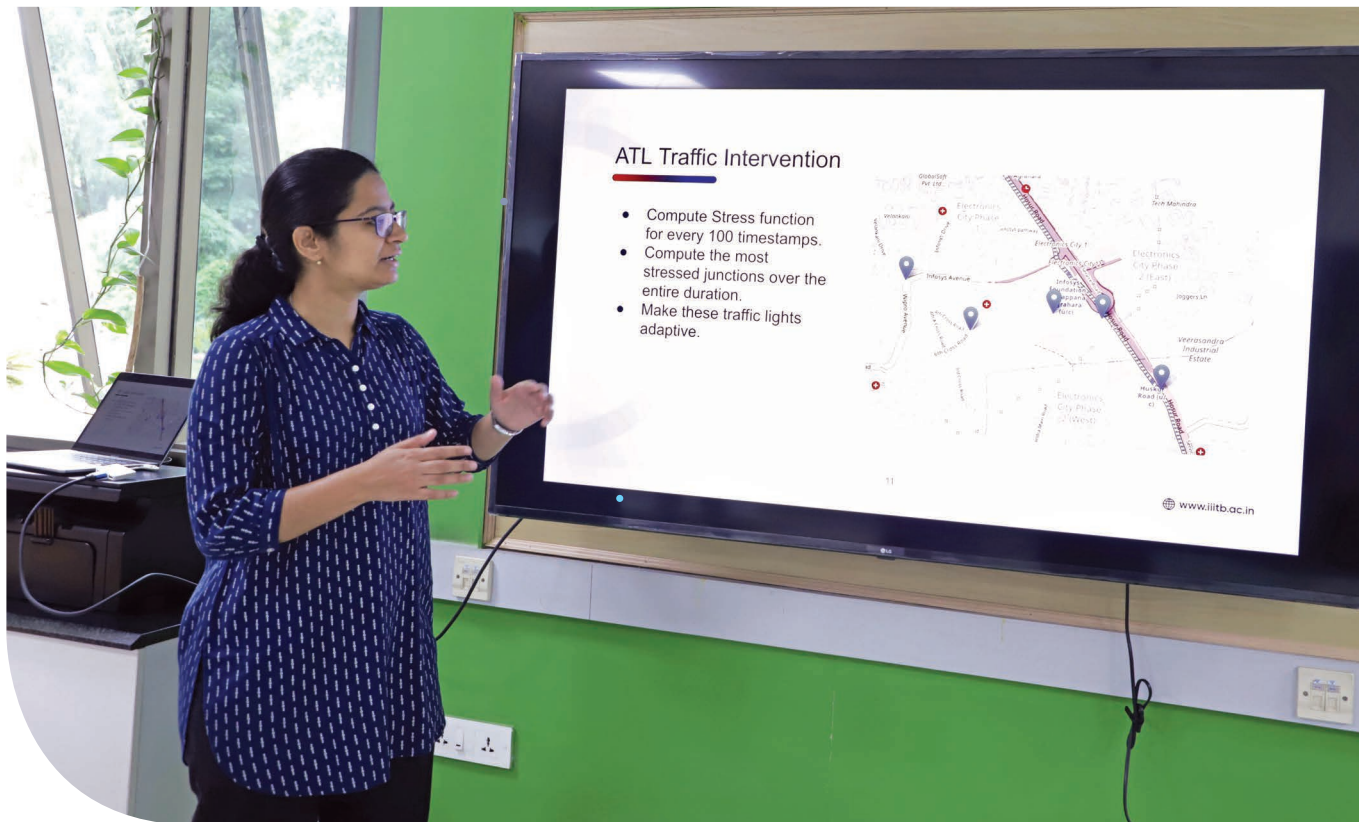
Above: Studying a simulation of traffic interventions at the International Institute of Information Technology, Bengaluru, Karnataka, India.

This report covers the subject of AI literacy in one chapter but is mainly focused on AI-powered educational technology. This latter field is also called Artificial Intelligence in Education (AIED) and is interdisciplinary in nature as it involves computer science, pedagogy and psychology. The scope of this report is restricted to AI in Education in India, while recognizing that many of its applications, as well as its opportunities and challenges, are pertinent on a global scale.

To define the scope of this report further, it is important to clarify what is not AI-powered educational technology. Educational technology is a wide field and many successful developments of educational technology in India do not involve AI. To make matters more complicated, educational technology products are occasionally promoted by the private sector or the media as 'AI-powered', owing to its reputation as a buzzword, when it is actually not the case. Although it is not always easy to draw the line, this report only discusses educational technology that integrates one or more of the disciplines specified by Russell and Norvig (2020), namely: natural language processing, knowledge representation, automated reasoning, machine learning, computer vision and robotics.

Methodology

This report is based on extensive desk research, interviews with experts and quantitative statistics from secondary sources.

Primary and secondary information was collected from the following sources:

- Documents, reports and data available in the public domain from agencies of the Government of India, such as the Ministry of Education (MoE), the National Institution for Transforming India (NITI) Aayog, the Central Institute of Educational Technology (CIET), etc., and international organizations such as UNESCO.

- National and international policy documents.

- International peer-reviewed journal articles.

- Online and in-person interviews with different stakeholders (policy-makers, AI experts and experts from government agencies and industries).

Structure

The focus of this report is AI-powered educational technology. This chapter gives an overview of the report and the remaining six chapters are outlined below:

CHAPTER 2 provides the specific context of this report.

CHAPTER 3 is dedicated to AI literacy in India.

CHAPTER 4 outlines the opportunities that AI-powered educational technology holds for India.

CHAPTER 5 describes the challenges that AI-powered educational technology faces in India.

CHAPTER 6 analyses the opportunities and the challenges and presents a conclusion as well as a vision for how responsible and human-centred application of AI could transform the education sector in India by 2030.

CHAPTER 7 offers concluding recommendations to advocate for and provide guidance towards responsible and human-centred application of AI in Education in India.

Specific subjects such as the effects of COVID-19 on AI in Education in India, how AI could support the achievement of SDG 4 in India, and what India can offer to the world in AI are featured throughout this report. In addition, this report also presents several case studies of promising AI in Education practices in India, organized in the following categories: tools for formal and informal learning, teaching, evaluation, school management, and mapping and matching of skills. Some case studies in this report also showcase notable AI literacy projects in India.

Opposite page:
A collaborative robot (CoBot) based on augmented reality and developed for healthcare. Indian Institute of Science, Bengaluru, Karnataka, India.
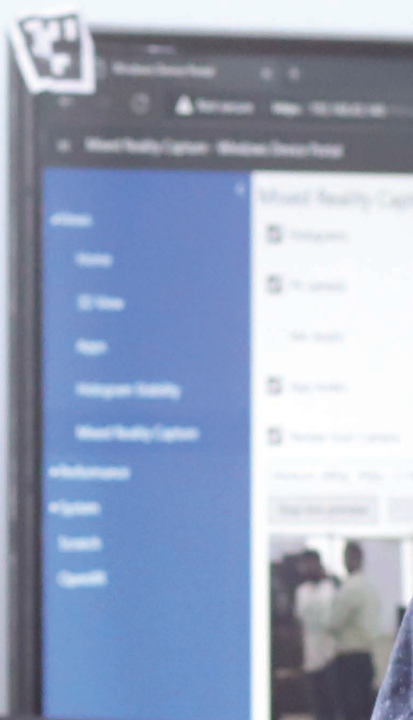
Introduction

This introductory chapter is divided into four sections, each aiming to provide contextual information for the subjects discussed later in this report. First, there is a brief overview of the history of AI and of AI in Education, followed by a synopsis of UNESCO's activities in the field of AI. Thereafter comes a summary of current AI activities and policies in India. The chapter concludes with an overview of challenges in the Indian education sector that may be addressed by AI in Education systems.

Left: A mixed reality-based advanced driver assistance system (ADAS). Indian Institute of Science, Bengaluru, Karnataka, India.

2 Introduction

Artificial Intelligence in general

With the rapid advancement of information and communications technology (ICT), Artificial Intelligence (AI) has evolved and been applied in healthcare, agriculture, cyber-security, autonomous vehicles, finance, logistics, e-commerce, entertainment, etc. Haenlein and Kaplan (2019) describe the evolution of AI technology as follows in Box 1.

BOX 1

The evolution of AI technology

THE BIRTH OF AI

In 1942, the science fiction writer Isaac Asimov invented the 'Three Laws of Robotics' and introduced them in his short story, 'Runaround', which told the story of a robot equipped with human-like qualities and features. This story inspired many scientists and led to the establishment of the Massachusetts Institute of Technology (MIT) AI laboratory. During the same period, the mathematician Alan Turing developed a code-breaking machine to decode the Enigma code used by the German army in the Second World War. Later, in 1950, Turing published an article, 'Computing Machinery and Intelligence', in which he explained the development and testing of the intelligent machines. John McCarthy coined the term 'Artificial Intelligence', which was used officially for the first time in the proposal for the so-called Dartmouth workshop, written by John McCarthy, Marvin Minsky, Nathaniel Rochester and Claude Shannon (McCarthy et al., 1955; Russell and Norvig, 2020). As Russell and Norvig (2020) note, no breakthrough was achieved at the Dartmouth workshop, which took place in 1956, because its participants underestimated the complexities of the subject. However, all the leading thinkers of that time in Artificial Intelligence met at this workshop and collaborated in this field for decades to come.

THE UPS AND DOWNS OF AI

Between 1964 and 1966, the computer scientist Joseph Weizenbaum developed a natural language processing (NLP) tool called ELIZA that could simulate a conversation with a human. This was followed by the development of a 'General Problem Solver program' by Herbert Simon, Cliff Shaw and Allen Newell, which could solve complex mathematical problems like the Towers of Hanoi. On the one hand, such success stories in AI attracted substantial funding for AI research. On the other hand, in 1973, the United States Congress criticized high spending on AI research. During the same time, mathematician James Lighthill also questioned the positive outlook proposed by AI researchers. According to Lighthill, 'machines would only ever reach the level of an "experienced amateur" in games such as chess and . . . common-sense reasoning would always be beyond their abilities' (Haenlein and Kaplan, 2019, p. 7). Such arguments led the United States and British governments to limit their funding of research in AI.

THE RISE OF AI

Insufficient computing power was one of the reasons for the lack of progress in AI in the early days. However, following advancements in computing technology in the twenty-first century, artificial neural networks, natural language processing and deep learning have brought disruption in the fields of image recognition, speech recognition, recommendation systems and automation.

Because of its advancement over the past two decades, AI has received a lot of attention from educators and has been widely applied in education. Hwang et al. (2020) defined Artificial Intelligence in Education (AIED) as 'the use of AI technologies or application programs in educational settings to facilitate teaching, learning, or decision making' (p. 1). There have been several paradigm shifts in AI in Education.

Ouyang and Jiao (2021) categorized these AI in Education paradigmatic shifts into three types: (1) AI-directed, where AI provides domain knowledge and directs the learning process while the learner acts a recipient and follows the specific learning path defined by AI. This is based on statistical relational AI techniques and grounded in behaviourism (e.g. Adaptive Control of Thought Programming Tutor) (Anderson et al., 1990);
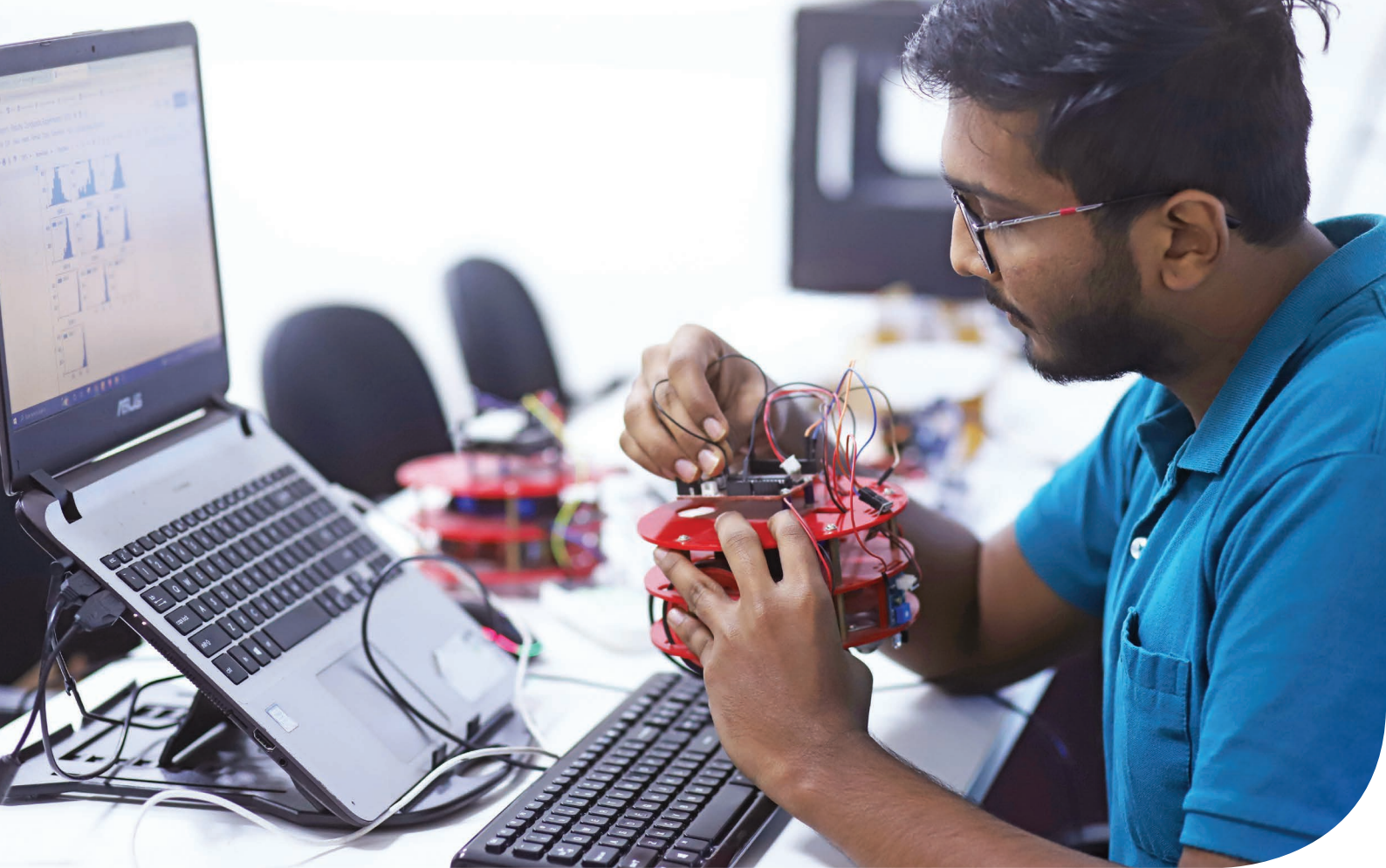
(2) AI-supported, where AI is used as a supporting tool and the learner acts as a collaborator with the system. This is based on Bayesian networks and NLP and is grounded in cognitive learning theory and social constructivism (e.g. ProPL) (Lane and VanLehn, 2004); and (3) AI-empowered, where AI is considered a tool to supplement human intelligence and learners as a core of AI in Education. This is based on machine learning (ML) and deep learning, grounded in connectivism learning theory and complex adaptive systems, for example Recurrent Neural Networks, which are neural networks used for sentiment analysis and video classification.

AI technologies can bring positive disruption to the education system by providing a personalized learning experience and real-time feedback and support to students, and by assisting teachers in tracking the learning performance of students and conducting large-scale assessments. Teachers can diagnose and identify students' problems in real time and provide interventions to improve students' learning outcomes (Ouyang and Jiao, 2021; Yang et al., 2021). In addition, AI can help policy-makers take precise decisions, based on the problems identified, to reform and reboot the education system (Hwang et al., 2020).

AI in Education can be traced back to the 1980s (Luckin et al., 2016) and indicators show that AI in Education is, by now, an established scientific

(sub)discipline. The AI in Education research community is organized within the International Artificial Intelligence in Education Society.[1] Among other activities, the society publishes the *International Journal of AI in Education* and arranges an annual conference.

As is the case with other sciences, AI has the potential to support a more precise understanding of how education works, and how it depends on and interacts with other parameters, which is phrased by Luckin et al. (2016, p. 17) as follows: 'AIED is also a powerful tool to open up what is sometimes called the "black box of learning," giving us deeper, and more fine-grained understandings of how learning actually happens (for example, how it is influenced by the learner's socio-economic and physical context, or by technology).'

Luckin et al. (2016) describe this in more detail: AI in Education systems create a 'worldview' through three so-called models, namely, a pedagogical model, a domain model and a learner model. The pedagogical model represents successful approaches to teaching, the domain model represents the subject to be taught and the learner model represents an individual student. As will be further outlined below, one of the innovative strengths of AI in Education systems is personalization, which means that they have different learner models for every student they teach.

NITI Aayog (2018) recognizes the potential of AI in Education to supplement pedagogy and to inform and support decision-making for all stakeholders involved in education.

Bottom: AI-powered education technology has enabled creative ways of teaching and learning. Hebbagodi Government School, Bengaluru, Karnataka, India.

Porayska-Pomsta and Holmes (2023) illustrate the interdisciplinarity of AI in Education, which includes educational, psychological and computational sciences as well as applied philosophy, as shown in Figure 1.

The public policy think tank of the Government of India, NITI Aayog (2018), recognizes the potential of AI in Education to supplement pedagogy and to inform and support decision-making for all stakeholders involved in education. It also recommends exploring how AI in Education systems could tackle challenges in the education sector in India.

FIGURE 1
Interdisciplinarity of AIED

Applied philosophy
Fundamental questions about learning and cognition; the role and nature of education in society

Research methodology
Models of learning, cognition, best pedagogies

Educational sciences

Psychological sciences

Applied philosophy

Computational sciences

Civil engineering
AI tools for learning and teaching

Source: Porayska-Pomsta and Holmes (2023)

Artificial Intelligence in UNESCO

“

AI could help humanity overcome many of the serious social problems it faces. But at the same time, AI presents a series of complex challenges, particularly in terms of ethics, human rights and security.

”

Audrey Azoulay
Director-General
of UNESCO[2]

Since AI impacts UNESCO's areas of expertise, education in particular, the Organization has been involved in this field for some time. UNESCO expects education to be profoundly transformed by AI, including in terms of teaching tools, ways of learning, access to knowledge and teacher training. While UNESCO acknowledges the immense opportunities that AI holds for the 2030 Agenda for Sustainable Development, the Organization also maintains that it is essential to tackle the ethical issues related to AI head-on, as part of UNESCO's overall effort to reduce inequalities in access to knowledge and research.

The adoption of the 'Recommendation on the Ethics of Artificial Intelligence' in November 2021 by UNESCO's General Conference at its 41st session was a special achievement for UNESCO, this being the first global standard-setting instrument on the Ethics of AI in the form of a recommendation (UNESCO, 2021b).

In addition, UNESCO has published several landmark documents on AI such as *Steering AI and Advanced ICTs for Knowledge Societies*, which focuses on the Rights, Openness, Accessibility to all, and Multistakeholder participation (ROAM) principles for AI (UNESCO, 2019b). UNESCO has also published *AI and*

Below: A student explores the endless dimensions of design thinking. Modern Public School, Delhi, India.

education: Guidance for policy-makers, which acknowledges that policy debates have been outpaced by rapid technological developments. The document provides guidance for policy-makers on how to use the opportunities while simultaneously confronting the risks related to AI and education (UNESCO, 2021e).

In 2019, UNESCO organized an 'International Conference on Artificial Intelligence and Education' and the outcome document, also known as the Beijing Consensus, provided guidance and recommendations on how best to harness the potential of AI technologies towards the achievement of SDG 4 on Quality Education, while applying a humanistic approach. The document closes with these words:

'Recalling the principles set forth in the Universal Declaration of Human Rights, we reaffirm UNESCO's humanistic approach to the use of AI with a view towards protecting human rights and preparing all people with the appropriate values and skills needed for effective human-machine collaboration in life, learning and work, and for sustainable development.' Beijing Consensus on Artificial Intelligence and Education (UNESCO, 2019a, p. 46).

In 2020, UNESCO launched an International Research Centre on Artificial Intelligence[3] in Ljubljana, Slovenia. The centre aims to maximize the benefits of AI to achieve the SDGs, but also conducts research related to the ethical, legal, openness and policy challenges of AI.

In 2021, UNESCO launched an AI Global Policy portal,[4] with partners, that aims to contribute to the following areas:[5]

- Provide advice and assistance to Member States on national policy and development programmes.

- Massive Open Online Course – AI and the Judiciary.

- Build teachers' competencies in teaching and using AI in Education systems.

- Build AI literacy and digital skills.

UNESCO has also appointed a Chair in Artificial Intelligence to study AI as a driver and component for solutions and strategies towards the achievement of the SDGs.[6]

---

[2] https://en.unesco.org/courier/2018-3/audrey-azoulay-making-most-artificial-intelligence

[3] https://ircai.org/

[4] https://globalpolicy.ai/en/

[5] https://globalpolicy.ai/en/unesco/

[6] https://www.k4all.org/project/aichair/
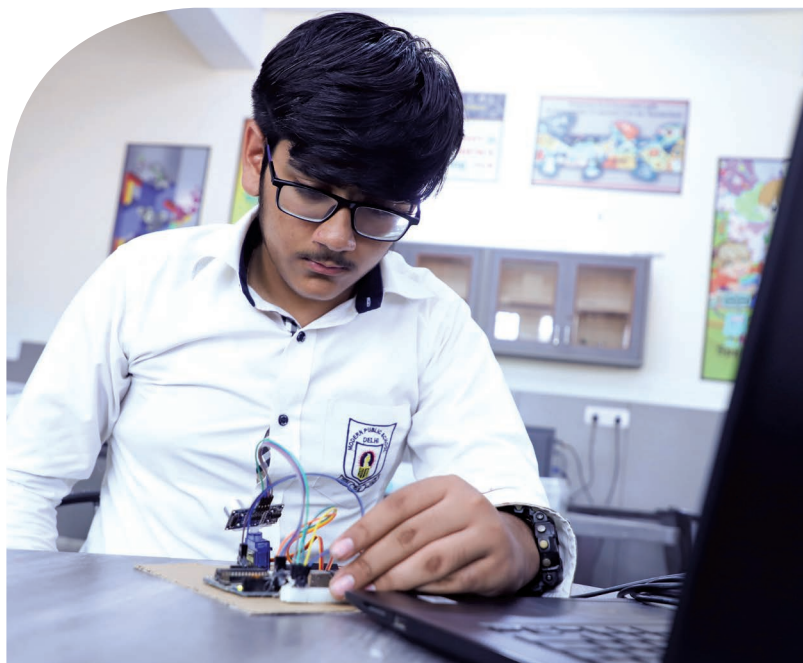
Artificial Intelligence in India

US$ **7.8** billion
is the expected AI market
in India by 2025

It is reported that the AI market in India is expected to reach US$7.8 billion by 2025 at the rate of 20.2 per cent compound annual growth rate (CAGR).[7] It is also predicted that the AI software market in India will grow to US$6.4 billion in 2025, at the rate of 18.1 per cent CAGR.[8] In addition, according to a NASSCOM (2020) report, it is expected that AI will add between US$450 billion and US$500 billion to India's gross domestic product (GDP) by 2025. Similarly, Accenture (2017) reported that AI is expected to increase India's growth by 1.3 percentage points by 2035. Venture capital investments in AI in India cover different sectors like financial and insurance services, healthcare, logistics, education and training, etc. (see Figure 2).

FIGURE 2
Total venture capital investments in AI in different industries in India
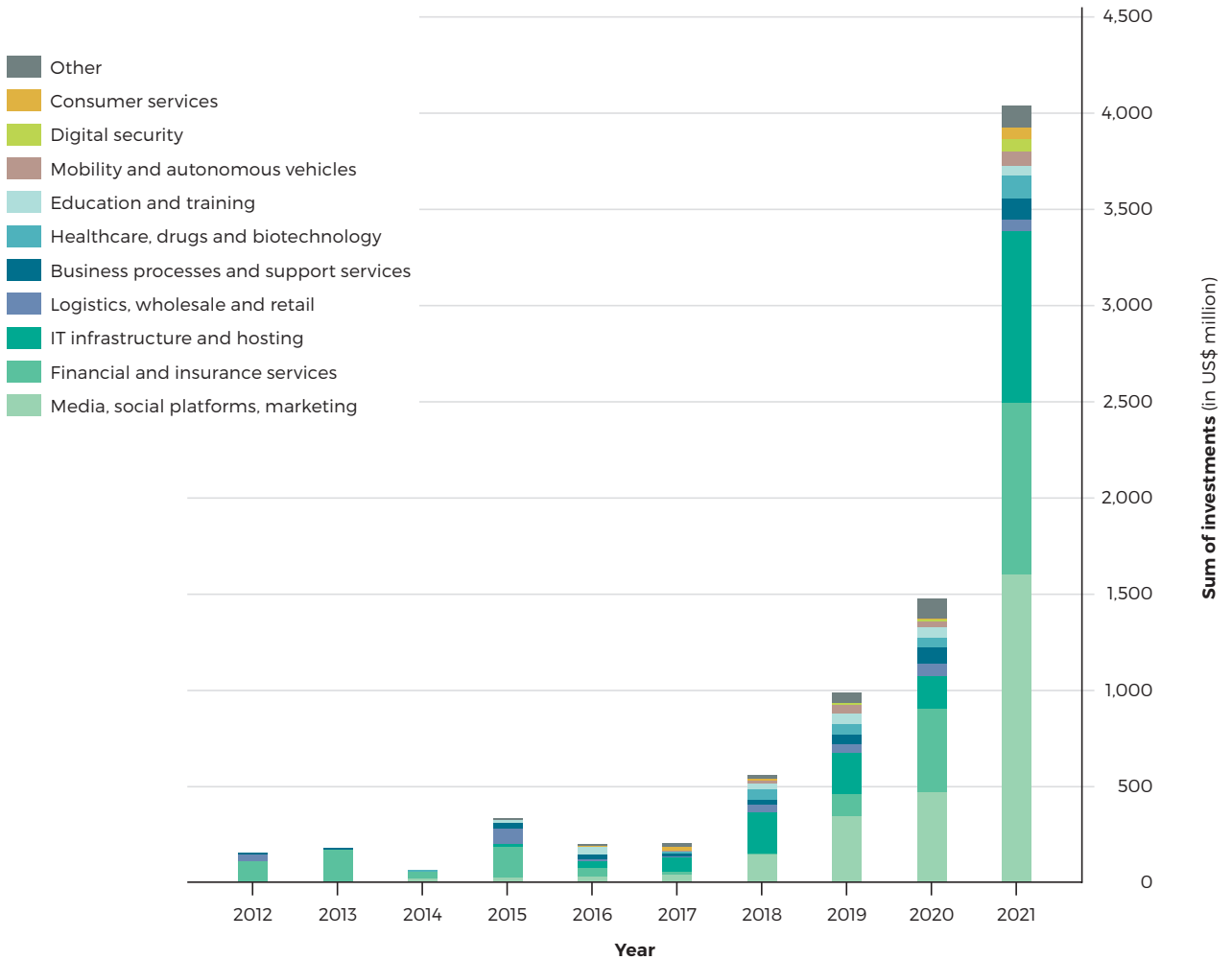
Source: OECD.AI (2022), visualizations powered by JSI using data from Prequin, www.oecd.ai (Accessed 24 May 2022)

India is collaborating internationally to develop AI software. By a margin, the European Union was India's top partner in 2022 (see Figure 3).

---

[7] https://indiaai.gov.in/article/india-s-ai-market-to-reach-usd-7-8-billion-by-2025-says-idc-s-latest-report-on-ai

[8] Ibid.

FIGURE 3
International collaboration by India in AI software development, 2022
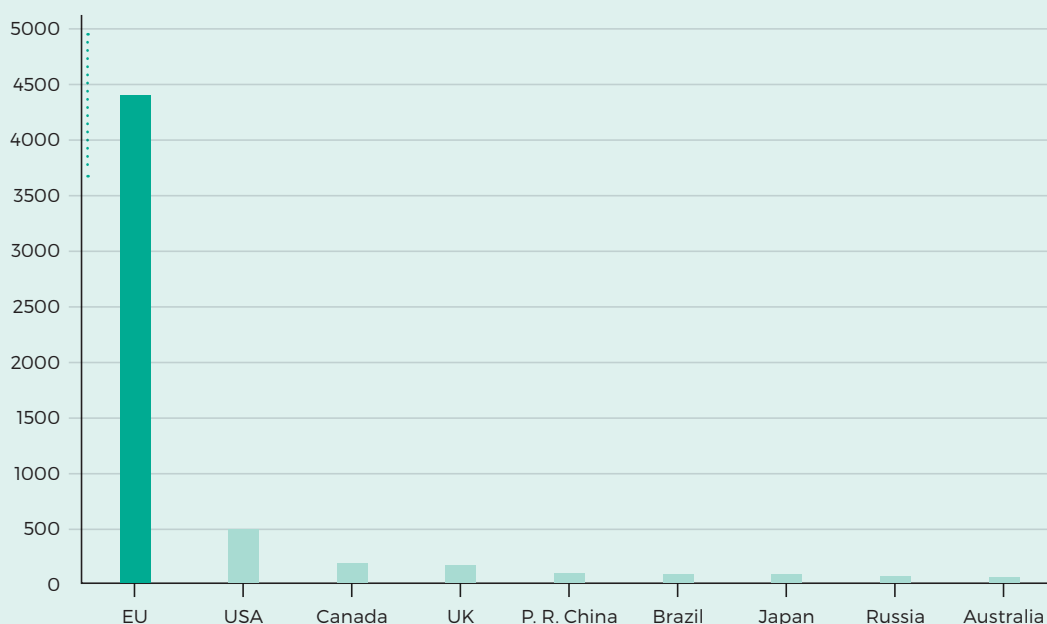
INR **30.54** billion

has been allocated
by the Government
of India to the National
Apprenticeship Training
Scheme (NATS)
for five years,
from 2022 to 2027

900,000

students will be provided
apprenticeships under the
NATS scheme in frontier
technologies like AI

The Government of India understood the potential of AI to transform millions of lives in the country and therefore identified five major areas for the use of AI-driven technology (NITI Aayog, 2018):

- **healthcare**

- **agriculture**

- **education**

- **smart cities and infrastructure**

- **smart mobility and transportation**

In 2018, the Ministry of Electronics and Information Technology of India (MeitY) constituted four committees to promote AI and to develop a policy framework for AI.[9] The following were the key recommendations from the four committees:

❶ Develop a National Artificial Intelligence Resource Platform of India that will create an ecosystem where people will build solutions using shareable data, information, tools, literature, etc. individually or in collaboration with others.

❷ Identify national missions to integrate AI in different key sectors like agriculture, health, education, etc.

❸ Support AI research for the challenges identified in the Indian context by providing sufficient research funding.

❹ Develop cyber security techniques and tools that use AI to defend against cyber-attacks more effectively.

The Government of India has allocated INR 30.54 billion to the National Apprenticeship Training Scheme (NATS) for five years, from 2022 to 2027. This scheme will provide apprenticeships to around 900,000 students in frontier technologies like AI (Government of India, 2022). In addition, the Open Government Data (OGD) Platform India[10] has been set up by the National Informatics Centre in compliance with the Open Data Policy of India under MeitY. The policy's primary objective is to provide proactive access to government-owned shareable data along with its usage information in open/machine readable formats through a wide area of networks across the country, in a periodically updated manner, within the framework of various related policies, rules and Acts of the government. It facilitates community participation towards further developing the product with visualizations, Application Programming Interface (APIs), alerts, etc. The Ministry of Education (2020a) highlighted the importance of AI in the education sector and advocated the development and implementation of new courses in AI for higher education to develop AI skills among students to meet the needs of present and future job markets. The Ministry of Education (2021a) also suggested leveraging the advantages of AI and ML in language and translation, personalized learning and enhanced learning.

---

[9] https://www.meity.gov.in/artificial-intelligence-committees-reports

[10] https://data.gov.in

TABLE 1
Overview of current AI policies/reports in India

Aim	Recommendations/strategies
National Strategy for Artificial Intelligence 2018 (NITI Aayog, 2018)	
Leveraging transformative technologies to ensure social and inclusive growth	• Enhance and empower human capabilities to address the challenges of access, affordability, shortage and inconsistency of skilled expertise using AI • Effectively implement AI initiatives to evolve scalable solutions for emerging economies • Develop a national strategy to build a vibrant AI ecosystem in India • Try to tackle some global challenges from AI's perspective • Develop guidelines for 'responsible AI' • Identify AI applications with maximum social impact • Improve access and quality of education using AI • Promote research in AI • Facilitate the adoption of AI solutions
National Education Policy 2020 (Ministry of Education, 2020a)	
Policy implementation in the country towards planning and adoption of technology to deliver quality education and develop a sustainable digital education system	• Develop curricula and pedagogy to introduce new subjects like AI and Design Thinking so as to develop important skills in students at all levels • Prepare professionals adept in cutting-edge technologies like AI • Offer postgraduate and doctorate programmes in AI/machine learning • Offer targeted training in low-expertise tasks that support the AI value chain, such as data annotation, image classification and speech transcription • Use natural language processing to translate textbooks into all Indian languages • Establish a National Research Foundation (NRF) to expand research in AI
National Digital Education Architecture 2021 (Ministry of Education, 2021a)	
A set of principles and approaches for the development of digital platforms and diverse solutions to serve the needs of learners, teachers and administrators of education within the education ecosystem and digital ecosystem in India to meet the goals of the National Education Policy 2020	• Enable personalized learning by leveraging AI/machine learning algorithms • Enable data collection in schools through AI tools • Focus on speech detection and analysis services for learning languages using AI/machine learning • Focus on personalized learning assistant solutions to help students learn at their own pace by leveraging AI/machine learning • Develop a set of reusable AI services, open-source libraries, open-source models and datasets for the education domain that can be leveraged and embedded within other building blocks
Responsible AI. Approach Document for India. Part 1 – Principles for Responsible AI (NITI Aayog, 2021a)	
Responsible management of AI systems by relevant stakeholders in India	Seven recommended principles: • Safety and reliability • Equality • Inclusivity and non-discrimination • Privacy and security • Transparency • Accountability • Protection and reinforcement of positive human values
Responsible AI. Approach Document for India. Part 2 – Operationalizing Principles for Responsible AI (NITI Aayog, 2021b)	
Identification of different mechanisms for the implementation of the seven principles for 'Responsible AI'	• Establish a multidisciplinary advisory body such as a Council for Ethics and Technology to formulate AI policies and act as a think tank for the development of quality research products related to AI • Private sector to ensure cost-effective compliance with AI standards • The government to establish awareness, accessibility and capacity-building, develop regulatory and policy measures, and support accurate procurement methods for AI

Source. Compiled by authors

Below are some examples of AI-based solutions developed in India in different sectors (see Tables 2 to 6).

TABLE 2
AI-based solutions developed in India – healthcare

Product name	Application
Microsoft Intelligent Network for Eyecare (MINE)[11]	Under the National Health Mission, the Government of Telangana collaborated with an AI platform, MINE, to eliminate avoidable blindness and to deploy AI for eye-care screening
SigTuple[12]	A data-driven platform that can automate the manual review of visual medical data and provide a pathology report without the need for a pathologist
CogniABle[13]	An AI-driven assistive technology to detect Autism Spectrum Disorder. CogniABle uses a video uploaded by the parents of their children as raw data and then applies computer vision techniques to identify gross motor skills, fine motor skills and other actions

TABLE 3
AI-based solutions developed in India – agriculture

Product name	Application
CropIn[14]	Helps monitor crop health and harvest estimation and provides alerts on pests and diseases
Microsoft AI Sowing App[15]	Determines the crop-sowing period using AI, based on previous climate data of a particular place, and sends messages to farmers alerting them of the optimal sowing period. In addition, it sends information regarding potential pest attacks based on weather conditions
TragNext[16]	An AI-based app that detects the quality of tea leaves. It improves the efficiency of the quality-checking process and also improves its overall accuracy

TABLE 4
AI-based solutions developed in India – smart mobility platforms

Product name	Application
BluSmart[17]	India's first all-electric ridesharing app driven by AI. Its features include smart mobility, smart parking and smart charging
OLA[18]	One of the leading ridesharing apps in India, it uses AI to track traffic and assign drivers available in the nearest location to customers, and uses ratings provided by customers to improve user experience
Zoomcar[19]	One of the largest self-driving car-sharing apps in India. It uses AI-powered algorithms to track the driving style of the driver and provides real-time feedback in case of reckless driving to avoid accidents and ensure safety. It also tracks the status of vehicles using computer vision and deep learning for regular maintenance of the vehicle to avoid breakdowns

Source: Compiled by authors (Tables 2 to 4)

---

[11] https://datacollaboratives.org/cases/microsoft-intelligent-network-for-eyecare-mine.html and https://indianexpress.com/article/technology/tech-news-technology/microsoft-launches-intelligent-network-for-eyecare-4435644/

[12] https://sigtuple.com/

[13] https://cogniable.tech/in/

[14] https://www.cropin.com/

[15] https://news.microsoft.com/en-in/features/ai-agriculture-icrisat-upl-india/

[16] http://tragnext.com/

[17] https://blu-smart.com/

[18] https://book.olacabs.com/

[19] https://www.zoomcar.com/in

Above: A bar bending simulator is a haptic training device that is combined with a virtual environment to provide manual skill training and help evaluate trainees. Amrita Vishwa Vidyapeetham, Kerala, India.

TABLE 5
AI-based solutions developed in India – Government of India initiatives

Product name	Application
MyGov Corona Helpdesk[20]	The world's largest AI-powered WhatsApp chatbot, it provided a 24/7 helpdesk to answer queries about the SARS-CoV-2 virus and helped prevent the spread of false information
PARAM SIDDHI AI[21]	Under the National Supercomputing Mission, PARAM SIDDHI AI, India's fastest supercomputer, was commissioned by the Centre for Development of Advanced Computing (Ministry of Electronics and Information Technology). Its primary aim is to execute large-scale projects in domains like healthcare, cybersecurity, agriculture, logistics, etc.
ATMAN[22]	The Defence Research and Development Organisation developed this AI-based application to detect COVID-19-induced lung abnormalities. ATMAN uses deep neural network techniques to classify an individual's chest X-ray images into normal, COVID-19-infected or pneumonic

TABLE 6
AI-based solutions developed in India – start-ups

Product name	Application
Scapic[23]	A cloud-based platform where people can create and share their immersive experiences using available augmented reality (AR) templates without needing any coding skills. Scapic is powered by AI and computer vision. The platform boosts e-commerce and marketing by providing an immersive product experience to consumers
NIRAMAI[24]	Non-Invasive Risk Assessment with Machine Intelligence (NIRAMAI) uses big data analytics and machine learning to analyse an individual's breast condition, automatically generate a report based on certain parameters and provide a breast health score
Chalo[25]	An app for people using public buses, it provides information about bus routes in real time based on an estimated-time-of-arrival algorithm. In addition, the app provides information about available seats by analysing videos from cameras installed in buses

Source: Compiled by authors (Tables 5 and 6)

20 https://play.google.com/store/apps/details?id=in.mygov.mobile&hl=en

21 https://dst.gov.in/indias-ai-supercomputer-param-siddhi-63rd-among-top-500-most-powerful-non-distributed-computer

22 https://www.drdo.gov.in/ai-based-intelligent-covid-19-detector-technology-medical-assistance-atman

23 https://www.scapic.com/

24 https://www.niramai.com/

25 https://chalo.com/

Academia

The Government of India has established centres to promote research and development in AI in different government-funded institutes and universities. In addition, some private universities have also founded centres to conduct AI research. Table 7 and Figure 4 list the top institutes and universities that conduct research in AI, amongst which the Indian Institute of Science (IISc) in Bengaluru is the frontrunner.

TABLE 7
Indian AI research institutes and universities

Institute/university name	Centre/group
Indian Institute of Science (IISc), Bengaluru	The Artificial Intelligence Group
Indian Institute of Technology (IIT) Kharagpur	The Centre for Excellence in Artificial Intelligence
Vellore Institute of Technology (VIT) University, Bhopal	Artificial Intelligence Division
IIT Bombay	The Centre for Machine Intelligence and Data Science
IIT Madras	The Robert Bosch Centre for Data Science and Artificial Intelligence
IIT Delhi	Yardi School of Artificial Intelligence
IIT Kanpur	Centre of Innovation and Translational Research
Amrita Vishwa Vidyapeetham Kollam	Atal Innovation Mission established Incubation (Amrita Technology Business Incubator) for AI and Deep Tech innovations

Source: Compiled by authors

FIGURE 4
Number of research publications on AI from institutes and universities in India
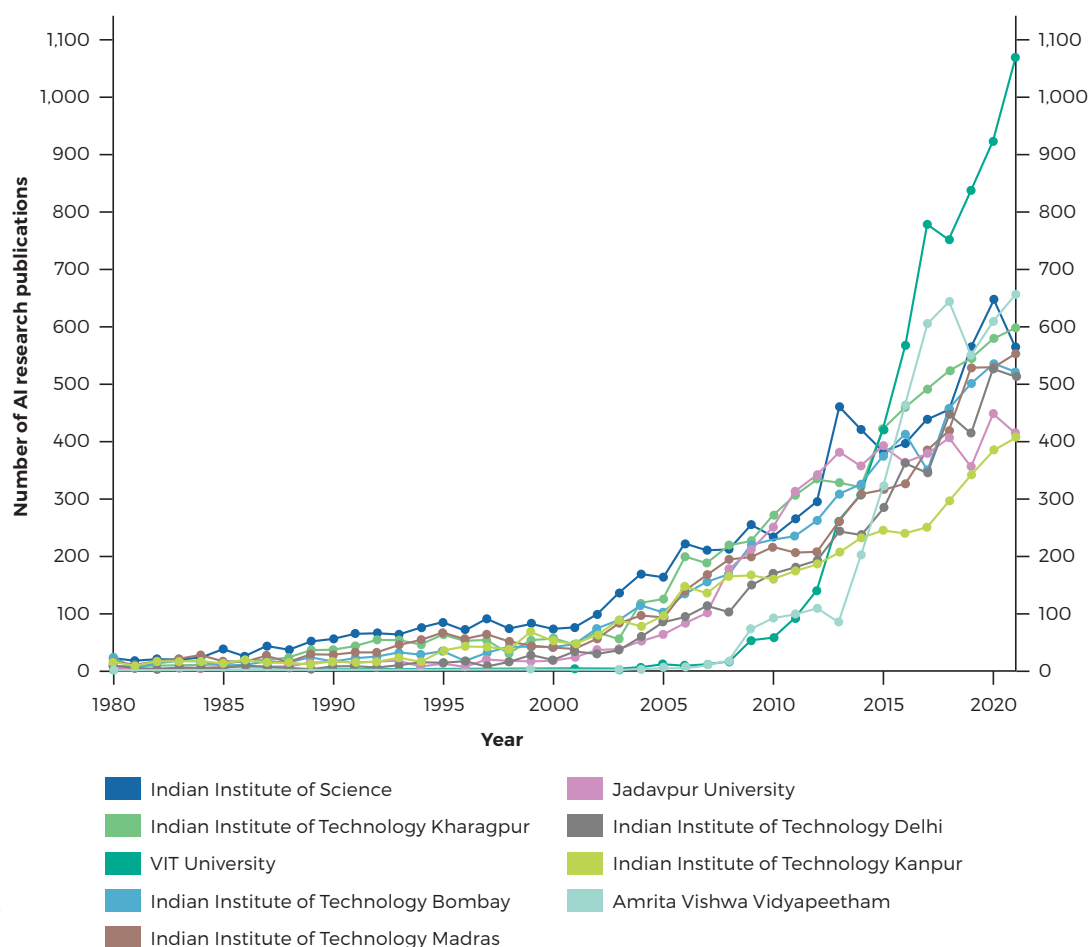
Legend:
- Indian Institute of Science
- Indian Institute of Technology Kharagpur
- VIT University
- Indian Institute of Technology Bombay
- Indian Institute of Technology Madras
- Jadavpur University
- Indian Institute of Technology Delhi
- Indian Institute of Technology Kanpur
- Amrita Vishwa Vidyapeetham

Challenges in the education sector in India

There are several challenges in the Indian education sector, of which lack of resources and infrastructure affect the expansion of AI in Education in particular (see Chapter 5: Challenges for India). Other issues are briefly outlined here:

Socio-economic issues

There exist significant socio-economic inequities in the Indian education sector. The National Statistical Office report on education in 2017–18[26] highlights that students from the richest 20 per cent of society are 17 times more likely to be studying law than those from the poorest 20 per cent. Students belonging to underprivileged castes are six times less likely to study management-related courses in India, and the gap is significantly wide in other fields of study also. The top 20 per cent of the population in terms of income is much more likely (39.1 per cent) to pursue engineering and technology-related courses, as compared to a disproportionately smaller segment (17.6 per cent) of the bottom 20 per cent. A student from the top 20 per cent of society is 10 times more likely to attend an English medium school than someone who belongs to the bottom 20 per cent. Region-based disparities also exist, with just 6 per cent of students in Bihar receiving an English medium education, compared with 63 per cent in Telangana and 95 per cent in Jammu & Kashmir. Hindi belt states fare badly vis-à-vis inter-caste inequality in English medium education.

Gender dimension

The literacy rate in India is 74.04 per cent, 82.14 per cent for males and 65.46 per cent for females.[27] According to the Gender Parity Index, India's completion rate for upper secondary education is 0.85, which indicates that gender parity favours males.[28] It is reported that around 1.6 million girls in India remain out of school, and 57 per cent of girls drop out upon reaching Grade 11 (CARE India, 2021).

Enrolment of girl students from underprivileged groups like the Scheduled Castes (SC) and Scheduled Tribes (ST) is significantly lower than enrolment of girls from more privileged groups. The enrolment of SC girls is 19.34 per cent at the elementary level, 18.6 per cent at the secondary level, and 17.3 per cent at the higher secondary level. For ST girls, it is 10.35 per cent at the elementary level, 8.6 per cent at the secondary level, and 6.8 per cent at the higher secondary level, which is a serious matter of concern (CARE India, 2021).

There are several reasons for low enrolment and high drop-out rates among girls in India. For example, Ramanaik et al. (2018) identified gender-related norms and poverty as important barriers to adolescent girls' secondary school retention and reasons for their dropping out. Unlike their male peers, girls are expected to undertake domestic and caring duties in the household. Socially and economically backward parents discontinue their daughters' education

26 https://www.drishtiias.com/daily-updates/daily-news-analysis/nso-report-on-education

27 https://knowindia.india.gov.in/profile/literacy.php#:~:text=The%20literacy%20rate%20in%20the,Mizoram%20(91.58%20per%20cent)

28 https://gem-report-2020.unesco.org/gender-report/

and make them work, either at home or as child workers (UNESCO, 2003). Child marriage is another reason behind the high drop-out rate for girls in India. Because of the financial burden of school fees, adolescent girls are pulled out from formal schools at puberty and married off (Raj et al., 2019; Ramanaik et al., 2018; UNESCO, 2003). Poor menstrual hygiene management in schools has been observed as contributing to girls' absenteeism (Vashisht et al., 2018). Lack of basic facilities such as water and toilet facilities, menstrual hygiene education and access to sanitary products are associated with increased absenteeism during menstruation (Ramanaik et al., 2018; Sivakami et al., 2019). Parents' concern for their girls' safety and security is another challenge for gender equality in education in India. Some girls have to travel a long distance to access education. At school or on the way to school, girls are often exposed to bullying and physical abuse, sexual and verbal harassment, and non-consensual touching (CARE India, 2021).

Teaching issues

According to UNESCO (2021a), high pupil-teacher ratios and lack of professionally qualified teachers are the biggest challenges in India's education system, and need a lot of attention. As per a National Coalition for Education report (NCE, 2020), 597,906 seats in secondary education and 316,865 seats in higher secondary education remain vacant. In addition, around 45 per cent of teaching positions in higher education are vacant. The report also highlighted that over 90 per cent of teacher training institutes are privatized and have poor accountability, which affects the quality of teachers. Moreover, it is very difficult for teachers to conduct assessments or provide individual attention in large classrooms, thereby affecting students' learning proficiency and influencing the quality of learning outcomes.

Drop-out rate

National Coalition for Education NCE (2020) highlighted the worrying drop-out rate in India, which stands at 19.8 per cent overall. In urban areas, around 40 per cent of students cannot complete their secondary education, and the figure is even higher in rural areas, at 70 per cent. According to the Indian Government's Unified District Information System for Education Plus (UDISE+) report for 2019/20,[29] the drop-out rate at the secondary school level in India is 16.1 per cent, while the drop-out rate at primary and upper primary levels is 1.5 per cent and 2.6 per cent respectively. The report also highlighted that approximately 30 per cent of students in India do not make the transition from secondary to higher secondary education. The drop-out rate for boys in primary classes was 1.7 per cent as

Below: A student codes a program that detects whether or not people are wearing masks. Modern Public School, Delhi, India.

29 https://dashboard.
udiseplus.gov.in/
assets/images/pdf/
UDISE+2019_20_Booklet.
pdf

67.5 %
of Indian households had access to smartphones in 2021

79 %
of children enrolled in private schools had smartphones

63.7 %
of children enrolled in government schools had smartphones

Above: Young students learn how to write code using online coding platforms. Modern Public School, Delhi, India.

Opposite page: Low-cost healthcare products that use AI being developed at Amrita Vishwa Vidyapeetham, Kerala, India.

30 https://thewire.in/education/more-boys-dropped-out-of-school-than-girls-at-secondary-level-in-india-in-2019-20-report

31 https://censusindia.gov.in/census.website/data/census-tables

32 https://www.epw.in/node/156434/pdf

33 http://rchiips.org/nfhs/NFHS-5_FCTS/Final%20Compendium%20of%20fact%20sheets_India%20and%2014%20States_UTs%20(Phase-II).pdf

34 https://www.borgenmagazine.com/digital-divide-in-india

against girls' 1.2 per cent. Similarly, the drop-out rate for boys was higher in secondary classes (18.3 per cent) than for girls (16.3 per cent). The report also revealed that only 22 per cent of schools in India had internet facilities in the academic year 2019/20, highlighting that the vast majority of schools would have fallen short in ensuring learning continuity for students through digital media as necessitated by the COVID-19 pandemic. The survey also revealed that less than 12 per cent of government schools had internet facilities and less than 30 per cent had functional computers.[30]

Linguistic barrier

India is a country of linguistic diversity, with over 19,500 languages and dialects currently used and spoken in India.[31] As such, the medium of instruction in schools is sometimes not the mother tongue, which results in students having difficulty comprehending concepts. It is also a huge challenge to provide digital learning content to cater to students with different linguistic backgrounds. The linguistic barrier is thus identified as one of the reasons for poor performance and high drop-out rates among students.[32]

Digital divide

As per the Annual Status of Education Report (ASER Centre, 2021), only 67.6 per cent of Indian households had access to smartphones in 2021, and more children enrolled in private schools had smartphones (79 per cent) than children enrolled

in government schools (63.7 per cent). Of enrolled children who had a smartphone available at home, 26.1 per cent were unable to access it for their studies. In remote areas, the non-availability of digital devices and non-access to high-speed internet connectivity widened the digital divide.

Technology is the vehicle driving modern society. During the COVID-19 pandemic, the world was forced to increase its reliance on technology further. This hastened the ongoing digital boom in India, with 622 million internet users and the lowest-priced internet data packs in the world, yet most Indians are unable to avail of this digital luxury (IAMAI and Kantar, 2021). According to a Ministry of Health and Family Welfare (2021) report, only 57.1 per cent of the male population and 33.3 per cent of the female population in India has ever used the internet. Moreover, there also exists a rural-urban digital divide. While 72.5 per cent of urban males and 51.8 per cent of urban females have access to the internet, these figures are much lower in rural India. The percentage of the rural population with access to the internet is only 48.7 per cent for males and 24.6 per cent for females. There also exists segregation in mobile phone ownership in rural and urban areas, especially in terms of gender. More urban women own mobile phones than rural women.[33] Apart from the urban-rural and gender digital divide, geographical constraints also exist. People living in remote, mountainous areas of the Himalayas, such as Himachal Pradesh, have less internet access as well.[34]

Clearly, there are still significant challenges to be addressed by the education sector in India, some of which AI could help to overcome. The following section discusses some AI-based solutions.

BOX 2

Impact of COVID-19 on AI in Education in India

The COVID-19 pandemic caused a major children's rights crisis globally. India was severely affected by the pandemic and schools were closed for a long time. A case study on the effects of, and responses to, COVID-19 on and by the education sector in India conducted by UNICEF and UNESCO revealed that distance learning exacerbated inequalities within the education system, as indicated by discrepancies in terms of capacity of teachers, learning outcomes, digital infrastructure provided by the government and access to technology (UNICEF and UNESCO, 2021). The Ministry of Education and other institutions in India have made efforts to establish access to digital learning through educational technology (not yet AI-powered) interventions, which include the following platforms:

DIGITAL INFRASTRUCTURE FOR KNOWLEDGE SHARING[i]
A national platform for school education based on the core principles of open architecture, open access, open licensing, diversity, choice and autonomy.

E-PATHSHALAI[ii]
A portal and mobile app serving as a storehouse of audio content, videos, epubs, flipbooks, etc. in Hindi, English and Urdu.

TECHNOLOGY ENABLED LEARNING[iii]
An overview of different platforms compiled by the Department of Higher Education within the Ministry of Education.

NATIONAL DIGITAL LIBRARY OF INDIA[iv]
A virtual repository of learning resources created by the Ministry of Education, which includes academic content by subject area for different levels of education, including lifelong learning.

SWAYAM PRABHA[v]
Channels devoted to telecasting educational programmes accessible across India. The channels air courses for higher education, school education (Grades 9 to 12), lifelong learners and also assist students (Grades 11 and 12) to prepare for competitive exams.

Although the UNESCO State of the Education Report for India 2021 highlighted the commitment of teachers to finding local solutions to ensure inclusion (UNESCO, 2021a), such efforts were hampered by an existing digital divide among both students and teachers in terms of access as well as skills, which then led to scepticism about distance learning (UNICEF and UNESCO, 2021).

Globally, during the pandemic, there was higher investment in AI to expedite various aspects of remote interaction, which benefited retail, healthcare and also education.[vi] UNESCO created online global overviews for distance learning solutions, which included only a few AI-powered tools.[vii] One example of the global challenges of AI in Education came from the United States, where students in the International Baccalaureate programme were assigned their marks by an AI-powered predictive grading system since they could not take their final exams due to the pandemic. However, students and experts accused the method of being discriminatory since the use of historical records may lead to bias against members of historically underprivileged groups.[viii]

Despite these known challenges (see also Chapter 5: Challenges for India), it has been claimed that if suitable AI-powered educational tools had been in place, they would have supported distance learning during pandemic-related lockdowns, and research on such systems has thus been intensified (Vincent-Lancrin, 2020). Distance learning leads to individual learning environments, and these are supported by some of the features and benefits of AI-powered educational tools, such as personalization and permanent access (Vincent-Lancrin, 2020; see also Chapter 4: Opportunities for India).

Another issue that became relevant during the pandemic was the authentication of students and prevention of cheating during remote exams (see, for example, Noorbehbahani et al., 2022), which is discussed in Chapters 4 and 5.

---

[i] https://diksha.gov.in/

[ii] https://epathshala.nic.in/

[iii] https://www.education.gov.in/en/ict-initiatives

[iv] https://ndl.iitkgp.ac.in/

[v] https://www.swayamprabha.gov.in/

[vi] https://www.weforum.org/agenda/2021/02/covid-19-increased-use-of-ai-here-s-why-its-here-to-stay

[vii] https://en.unesco.org/covid19/educationresponse/solutions and https://en.unesco.org/covid19/educationresponse/nationalresponses

[viii] https://news.trust.org/item/20200721145229-gm15u/

Artificial Intelligence-based solutions

Chapter 4 of this report offers a detailed description of how these challenges in the Indian education sector may be addressed by AI-powered tools. UNESCO (2019a) has advocated that the implementation of AI in Education systems can revolutionize the teaching-learning process. Below are some examples of where AI techniques could be used:

FORMAL LEARNING (ML)
Teachers can use intelligent tutoring systems as supporting aids to conduct assessments, track learning progress and provide regular individual feedback.

FORMAL AND INFORMAL LEARNING (NLP)
NLP techniques can help translate digital content into different languages, which can help students understand concepts in their mother tongues. AI provides learning opportunities and access to online learning materials in remote areas that may not have access to comprehensive physical infrastructure.

TEACHING (ML/NLP/COMPUTER VISION)
Using AI (face recognition, speech recognition, augmented reality/virtual reality (AR/VR) labs) smart schools and universities can be created to deliver quality content to remote locations.

EVALUATION (COMPUTER VISION)
AI-based techniques like image recognition and computer vision can assist teachers in grading large classrooms and help to reduce workload (Chen et al., 2020). For example, Sanna et al. (2012) developed an automatic evaluation tool for a Graphic and Virtual Design (GVD) curriculum, which exploits computer vision and image analysis algorithms to evaluate students' 3D-modelling work.

SCHOOL MANAGEMENT (ML)
Wang (2021) argues that the integration of AI in school management can save much time for teachers. Non-teaching tasks such as taking attendance and tracking students' learning progress may be automated using AI, which could reduce teachers' workload. This will provide more opportunities for teachers to develop a one-to-one relationship with students and to collaborate with colleagues for more effective output in teaching. With respect to the problem of dropping out, AI can monitor the learning activities of registered students. Based on learning behaviour parameters, the system can track students who are facing difficulties and send feedback to their instructors to help them take remedial measures to support the students. AI-based systems can help teachers identify learning styles and individual needs and allow teachers to customize learning content based on students' preferences.

MAPPING AND MATCHING OF SKILLS (ML)
AI can help job seekers find the right job based on registered users' information, which includes education, skills and goals. In addition, AI can also recommend the skills/training required for a particular job, and the user can complete the relevant course to avail of a particular job. This can help meet the demands of a skill-based workforce for Industry 4.0, or the Fourth Industrial Revolution, in which we see the transformation of industry through the intelligent networking of machines and processes with the help of information and communications technology.

Opposite page:
A woman researcher tests an AI-powered health monitoring tool to check her colleague's heart rate. Amrita Vishwa Vidyapeetham, Kerala, India.

Below: Students combine interdisciplinary aspects of science, technology, engineering, the arts and mathematics (STEAM) to develop sensors to detect moisture in soil. Modern Public School, Delhi, India.
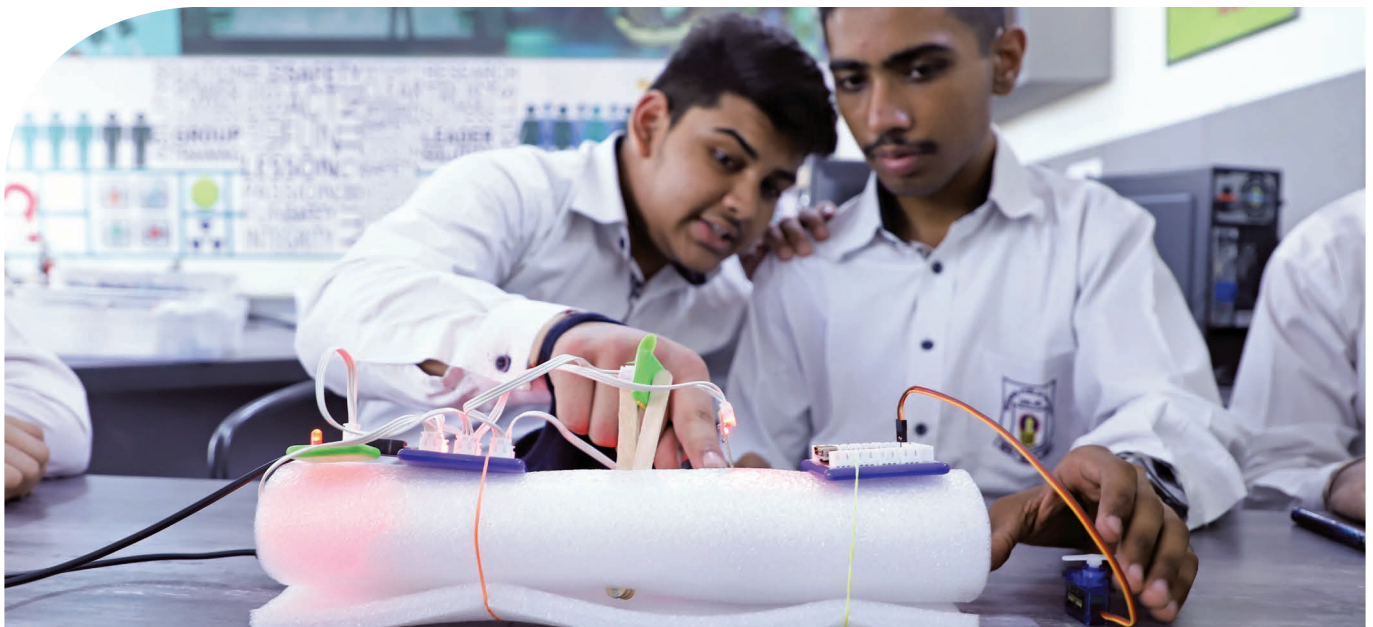
Summary

AI-driven technology is going to help India's GDP growth.

Indigenous AI-based solutions are being developed in India for different sectors like healthcare, agriculture, smart mobility and government initiatives to accelerate efficiency and efficacy.

The Government of India has understood the potential of AI and therefore emphasized the integration of AI in Education under the NEP 2020 to promote quality and skill-based education to meet the demands of Industry 4.0.

There are different challenges in the education sector in India, including socio-economic inequities, gender inequalities, insufficient teachers and inadequate teaching quality, high drop-out rates, linguistic barriers and the digital divide.

AI can provide possible solutions for these challenges using AI techniques like ML, NLP, learning analytics, computer vision, etc.
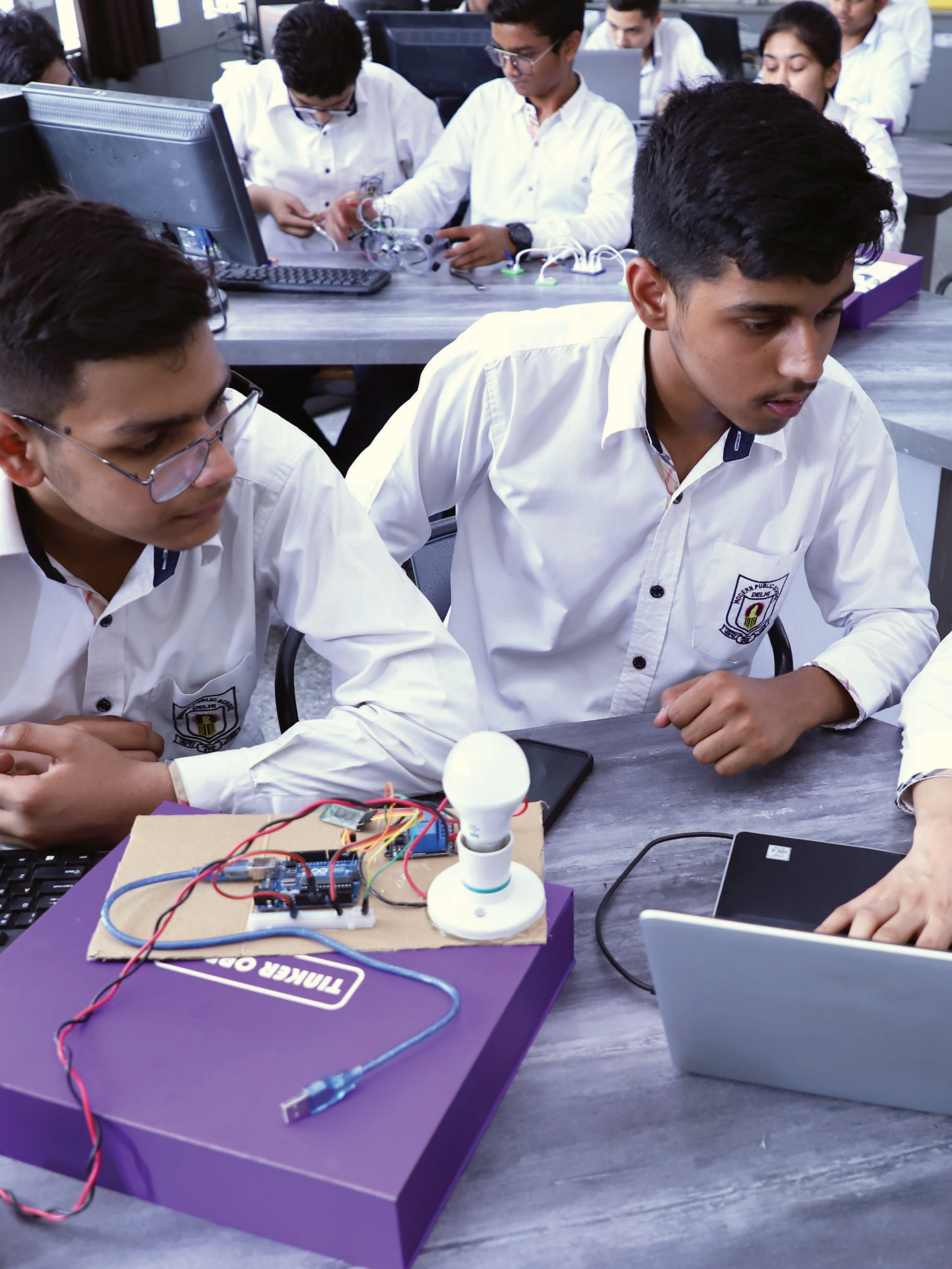
AI literacy in India

As explained in Chapter 1, AI literacy is distinct from AI-powered educational technology. This chapter is about AI literacy and discusses several aspects of this subject: what AI literacy comprises and why it is important in India; AI as a subject in Indian curricula; what challenges remain, particularly for girls, women and disadvantaged socio-economic groups; and to what extent students in India have successfully mastered this subject. This is the only chapter in this report that is not about AI-powered educational technology.

Left: Students experiment with technology and robotics. Modern Public School, Delhi, India.

3 AI literacy in India

AI literacy in general

In its synthesis report on *The International Forum on AI and the Futures of Education*, which focused on the theme of 'Developing Competencies for the AI Era', UNESCO underscored the importance of AI literacy (UNESCO, 2021d). To use the explanation contained in the synthesis report: 'AI Literacy comprises both Data Literacy, or the ability to understand how Artificial Intelligence collects, cleans, manipulates, and analyses data, as well as Algorithm Literacy, or the ability to understand how the AI algorithms find patterns and connections in the data, which might be used for human-machine interactions.' The report goes on to note that 'While there is growing attention to Data Literacy, Algorithm Literacy remains largely overlooked.' (p. 6).

Another categorization of AI literacy revolves around the distinction between the technical and the social aspects of AI, with the second dimension often overlooked, unfortunately. As is true for any new technology, it is critical to be well informed, not only about the benefits of AI, but also about its limitations and risks. This means that there is also a strong link between AI and social and human sciences, since AI systems must not only protect human rights but should also steer societies towards the larger social good. Thus, there are two categories of AI literacy: technological and human (W. Holmes, personal communication, May 2022). While its technological dimensions are more relevant to learners who intend to work in the field of Artificial Intelligence, its human dimensions, despite being often neglected, are relevant to all individuals who have to deal with AI, which is likely to be everyone in the future. It should be fundamental for those dealing with AI to be aware of its potential impact on humanity. This includes (at least) basic knowledge of the challenges of AI, as outlined in Chapter 4, and the lack of transparency of AI systems, issues of data privacy, algorithmic biases, etc.

For India, such education towards AI literacy in both its technological and human dimensions can actually be seen as a global responsibility, since so many Indian AI-trained individuals go and work abroad (see Box 5 in Chapter 4 – What can India offer to the world in AI?). With the benefit of international exposure and outreach, these professionals should ensure that developments in AI remain safe and target the larger social good.

Right: Students collaborate on a project to code a program for AI-based colour detection. Modern Public School, Delhi, India.

Opposite page: For a school project, students used AI concepts to solve real-world issues. Delhi Public School Bangalore East, Bengaluru, Karnataka, India.

The relevance of the humanistic, ethical and social aspects of AI literacy is also highlighted in UNESCO's *Recommendation on the Ethics of Artificial Intelligence*.

> ❝
>
> 106. Member States should develop, in accordance with their national education programmes and traditions, AI ethics curricula for all levels, and promote cross-collaboration between AI technical skills education and humanistic, ethical and social aspects of AI education. Online courses and digital resources of AI ethics education should be developed in local languages, including indigenous languages, and take into account the diversity of environments, especially ensuring accessibility of formats for persons with disabilities.
>
> ❞

Recommendation on the Ethics of Artificial Intelligence (UNESCO, 2021b)

As Colin de la Higuera, the UNESCO Chair in Open Educational Resources, Nantes University, France, points out, Artificial Intelligence has been taught in universities for over three decades but has only recently been included in K-12 curricula and in a limited manner (de la Higuera, 2019). Apart from the fluidity of the field of AI, another explanation for the delay in the global spread of AI literacy is the limited number of teachers trained in AI, which is a challenge that applies to India also. De la Higuera recommends that AI literacy comprise the following five pillars: data awareness, uncertainty and randomness, coding and computational thinking, critical thinking, and post-AI humanism.

UNESCO has recently published a mapping of K-12 AI curricula (UNESCO, 2022), which refers to an AI Literacy Competency Framework developed by Long and Magerko (2020), comprising the following seventeen competencies: recognizing AI, understanding intelligence, interdisciplinarity, general versus narrow AI, AI strengths and weaknesses, imagine future AI, representations, decision-making, machine learning (ML) steps, human role in AI, data literacy, learning from data, critically interpreting data, action and reaction, sensors, ethics, and programmability.

What may be considered another dimension of AI literacy is the ability to navigate a world surrounded by AI. This aspect includes handling the AI-powered education tools described in this report as well as many other AI-powered tools, and could also be described as human and machine 'fusion skills' (Daugherty and Wilson, 2018). In this regard, another critical component of being AI literate is for teachers and students to be able to recognize what AI can and what AI cannot (yet) do; to know, in other words, what the limitations of AI are.

What applies to all aspects of Artificial Intelligence is that it is a developing field, which stresses the importance of lifelong learning. People with degrees in AI must stay abreast with progress in the field or risk losing the AI literacy they have acquired. This is also valid for the human dimensions of AI, as various challenges, risks and ethical issues of AI may still be unknown.

Relevance of AI literacy in India

AI literacy is becoming relevant globally for various reasons, of which the most notable are economic reasons and the related demand for AI skills in the labour market. This also applies to India, as this section shows.

While it is beyond the scope of this report to explore this aspect of AI in the labour market, it would be remiss not to mention the concern that even as additional jobs will be created for AI-literate people, many other jobs may be lost globally, including in India, due to AI-based automation. A report by McKinsey (Manyika et al., 2017) is optimistic for India in this regard and projects that while 57 million jobs will be eliminated in India due to AI and automation, 114 million, or twice as many, new jobs will be created due to AI technologies. However, Stapleton et al. (2021) paint a bleaker picture and show that growth in AI demand in India has a negative effect on the growth, as well as the wages, of non-AI jobs. Between 2010 and 2012 and between 2017 and 2019, a 1 per cent increase in the AI vacancy growth rate was accompanied by a 3.6 per cent decrease in the growth of non-AI vacancies and a 2.6 per cent decrease in the growth of non-AI wages within establishments. This illustrates the potential double-edged impacts of AI (Stapleton et al., 2021).

NITI Aayog (2018) acknowledges the relevance of AI literacy and sees it as a national priority. India has the advantage of having an advanced information technology (IT) sector and a large number of young people who will join the labour market in the near future. Yet, NITI Aayog also stresses the insufficient availability of qualified AI faculty and researchers in India. A high number of science, technology, engineering and mathematics (STEM) graduates are not immediately employable upon graduation, which is partly because of low levels of interdisciplinary research in AI-related sectors. In addition, NITI Aayog observed poor outcomes in mathematics and reading at the K-12 level; both of these are core subjects for AI literacy. To rapidly alleviate the situation, NITI Aayog recommends reskilling the current workforce towards AI literacy and prioritizing subjects relevant to AI in the education sector overall, starting from primary and secondary schools.
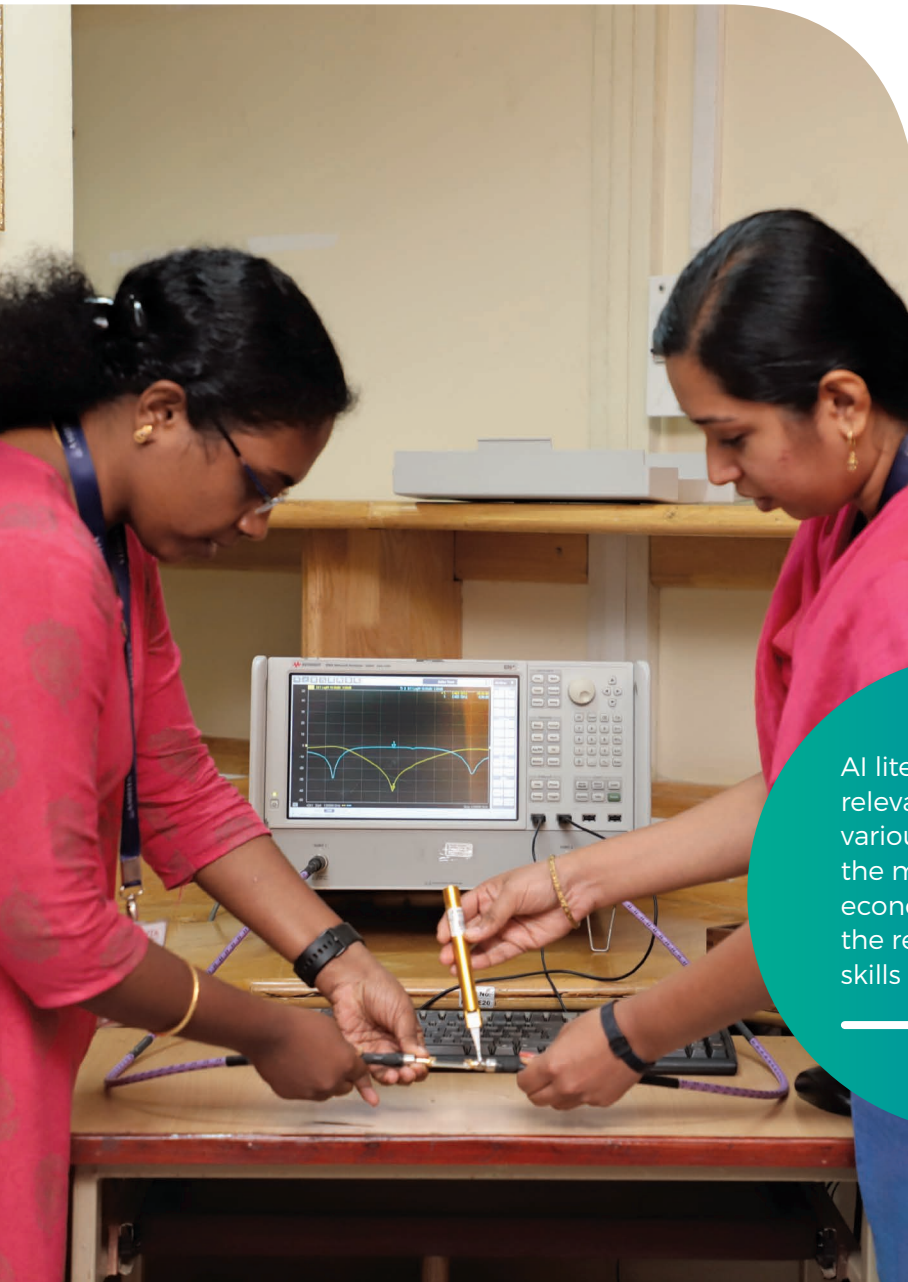
> AI literacy is becoming relevant globally for various reasons, of which the most notable are economic reasons and the related demand for AI skills in the labour market.

Left: Involving more women in STEM subjects remains a priority. Amrita Vishwa Vidyapeetham, Kerala, India.

CASE STUDY 1

Atal Innovation Mission
AI literacy

The Atal Innovation Mission (AIM) was initiated in 2016 by the Government of India to create a space for innovation and an entrepreneurial ecosystem, and focuses on empowering the youth with twenty-first-century skills such as creativity, innovation, critical thinking, design thinking, social- and cross-cultural collaboration and ethical leadership. AIM established Atal Tinkering Labs (ATLs) across India with a vision of 'cultivating one million children in India as Neoteric innovators.' The Tinkering Labs' main objectives include creating workspaces where young minds can innovate by sculpting ideas through hands-on experience and work, and by learning in a flexible environment, to promote AI literacy.[i]

As of December 2020, over 14,000 schools have been selected for the establishment of ATLs. These schools are spread across 90 per cent of Indian districts. Among them, 70 per cent are government or government-aided schools and over 70 per cent are girls' or co-educational schools.[ii] Over 8,706 schools have received the ATL sanction and grant-in-aid. The grant-in-aid is of up to INR 2 million per year, of which INR 1 million is provisioned for establishment costs and INR 1 million is allocated for operations and maintenance for five years (NITI Aayog, 2021c).

Under the Atal Innovation Mission, the Atal Tinkering Labs introduced a curriculum that includes physical computing, an Internet of Things module, a space module, a drone module, Artificial Intelligence, a Python learning module, a gaming module, an app development module, WNS Cares Foundation's CyberSmart Portal, 3D design and printing, and modules on intellectual property, creating a business pitch and Ethical Leadership in Tinkering and Innovation (ELTI).[iii] There are plans to establish 1,000 ATLs in Jammu & Kashmir in various educational institutions, including Kendriya Vidyalayas, Jawahar Navodaya Vidyalayas and private schools.[iv]

An 'ATL AI Base Module' curriculum was introduced in February 2020, and made for students with no prior knowledge of Artificial Intelligence. It is specially designed to cultivate curiosity in learners as young as 12 years of age. The module is supposed to be implemented across 5,000 Atal Tinkering Labs in the country, benefiting 2.5 million students. Students will get AI kits developed by technology companies like Adobe, SAP Labs, Microsoft, Wipro and NASSCOM. These ATLs will have workspaces of 1,200 to 1,500 ft^2, with kits on the latest technologies like 3D printers and robotics.[v] In August 2020, ATL collaborated with NASSCOM to launch the 'ATL AI Step-Up Module' as a follow-up module to encourage hands-on experience and application of AI in everyday life.[vi]

---

[i] https://aim.gov.in/atl-overview.php

[ii] https://aim.gov.in/

[iii] https://aim.gov.in/atl-curriculum.php

[iv] https://www.thehindu.com/news/national/other-states/1000-atal-tinkering-labs-to-come-up-in-jammu-and-kashmir/article37921072.ece

[v] https://economictimes.indiatimes.com/industry/services/education/atal-innovation-mission-nasscom-tie-up-to-launch-ai-based-module-in-5000-atls/articleshow/74333741.cms?from=mdr

[vi] https://blog.mygov.in/atl-ai-modules/

As of August 2020, the AI market in India was valued at US$6.4 billion, which includes all AI operations originating from India (Analytics India Magazine and Jigsaw Academy, 2020). Figure 5 illustrates how a steady growth of this market is expected in the following years.

FIGURE 5
Estimated AI market size in India (in US$ billion)

- AI market excluding IT services
- Entire AI market including IT services

Source: Analytics India Magazine and Jigsaw Academy, 2020
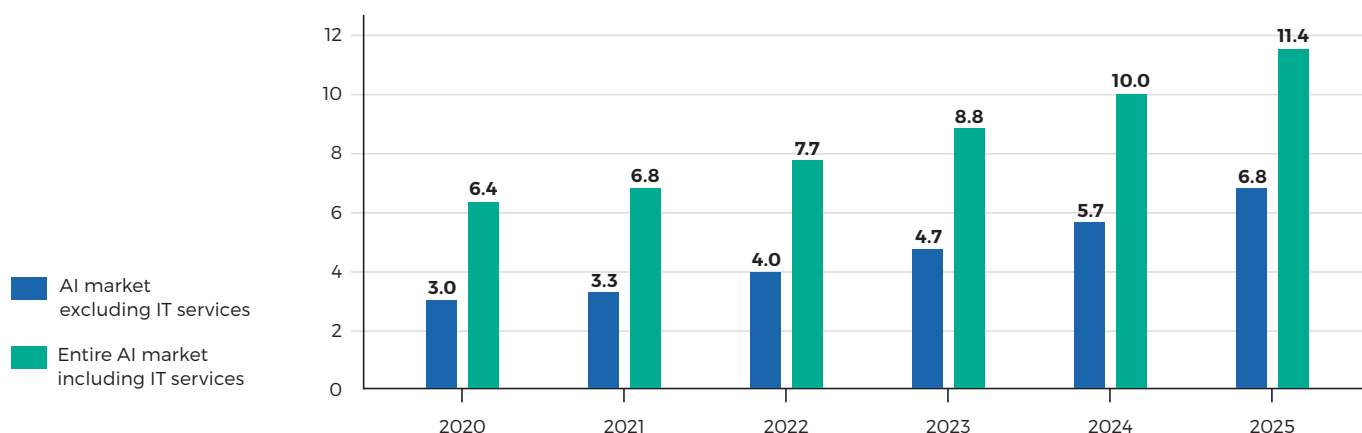
India's growing AI market would make AI the primary growth driver of the country's broader IT and data science industry. Figure 6 shows the market share of AI by industry in India.

FIGURE 6
Industry-wise market share of AI in India (%)
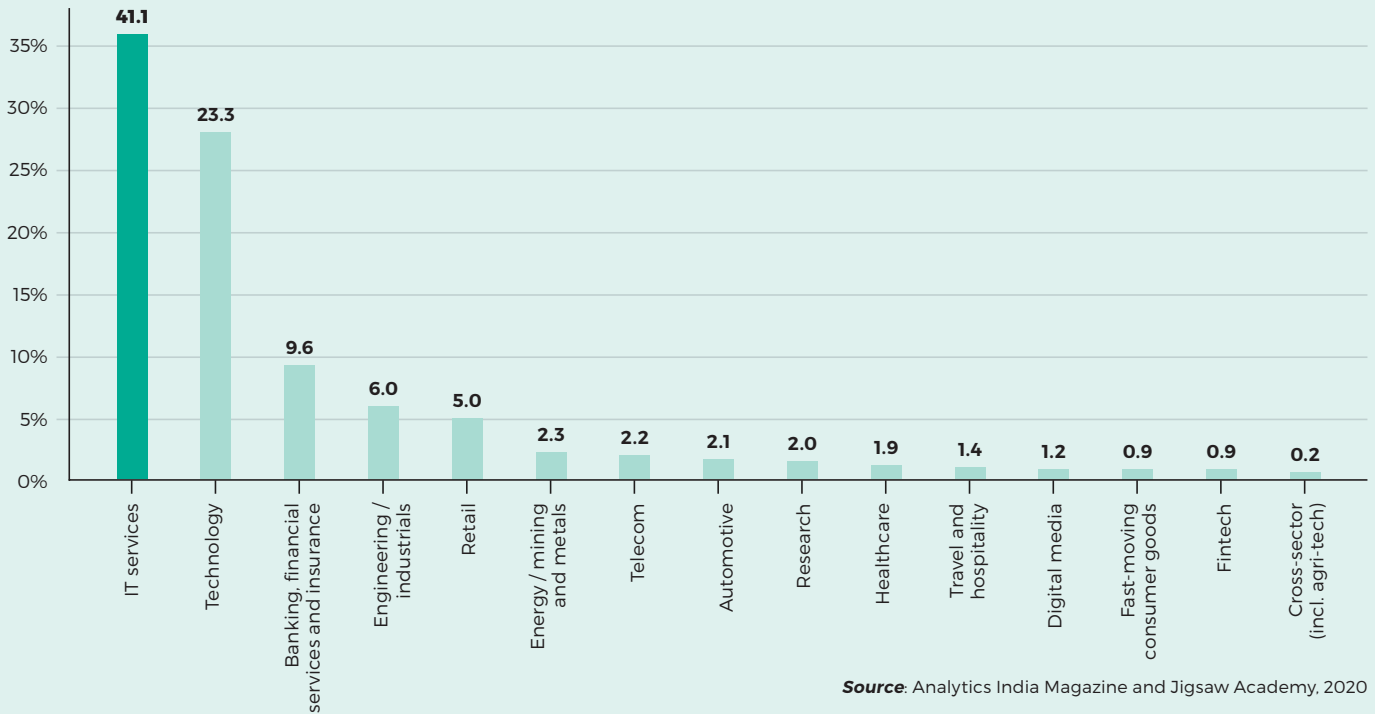
Source: Analytics India Magazine and Jigsaw Academy, 2020

As regards the AI labour market and according to the *Artificial Intelligence Index Report 2021*, India had the world's second-highest growth in AI hiring from 2016 to 2020, behind Brazil and ahead of Canada, Singapore and South Africa (Zhang et al., 2021).[35] Analytics India Magazine and Jigsaw Academy (2020) report that there were almost 91,000 Artificial Intelligence-related staff working in India with 16,500 job openings as of July 2020. The median annual salary was INR 1.47 million, with the highest median salary, of INR 1.67 million, being paid in Mumbai.

FIGURE 7
Experience-wise open jobs distribution requiring AI literacy (%)
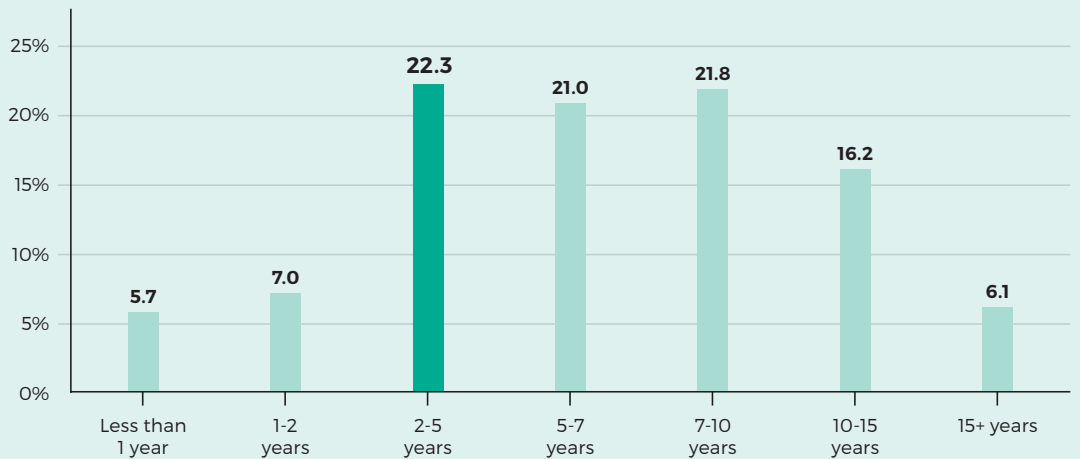
Source: Analytics India Magazine and Jigsaw Academy, 2020

---

[35] For their latest *Artificial Intelligence Index Report 2022*, Zhang et al. (2022) changed their methodology to a 'relative AI hiring index'. In this index, India did not make it to the top fifteen.

FIGURE 8
Industry-wise open jobs requiring AI literacy (%)
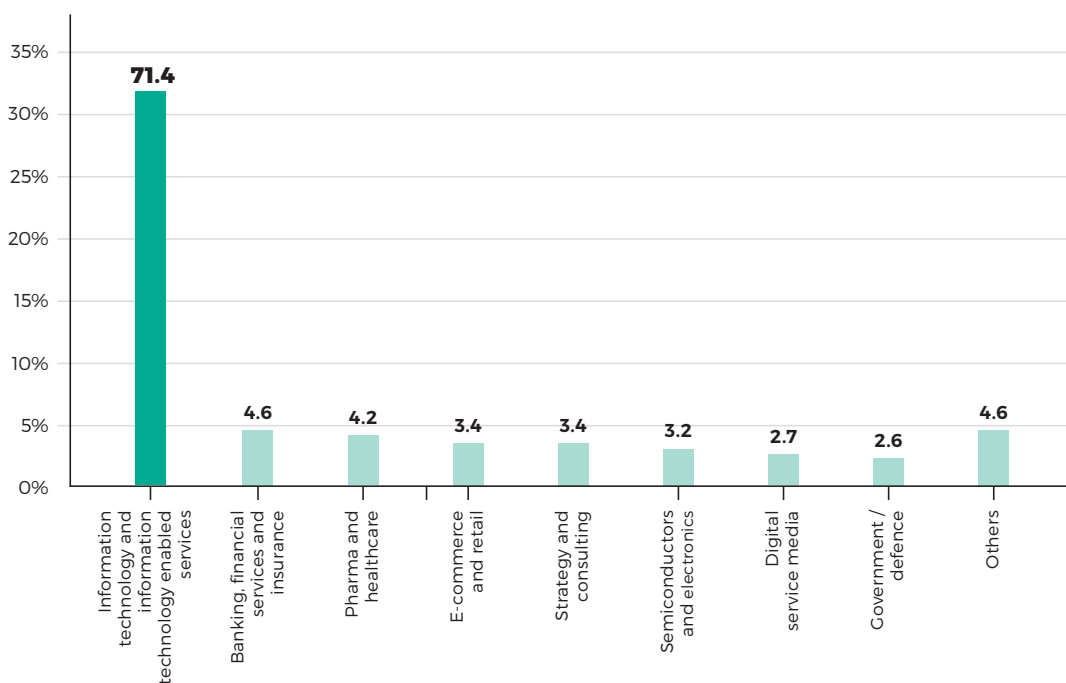
Below: Student testing an eye gaze-controlled head-up display for cars. Indian Institute of Science, Bengaluru, Karnataka, India.

Figure 7 and Figure 8 give relevant information for people aspiring to work in the AI sector. For example, Figure 7 shows that only 5.7 per cent of AI job openings are for beginners, while the vast majority of available positions require several years of relevant experience. Figure 8 illustrates the industries in which AI literacy is most sought-after. The demand for AI expertise is usually with application to another discipline, such as education, which is the field this report focuses on. Therefore, it is often useful, if not required, to have both AI literacy and additional knowledge of the field of its application. For example, those who wish to become competent in AI in Education should study both AI and a field in education.

Intel and the Indian School of Business (ISB) (2020) conducted a 'Suitability of Machine Learning' survey of over 3,000 stakeholders, which revealed another aspect related to AI literacy. Eighty per cent of the respondents expected that their staff would have to undergo significant retraining over the following two years owing to the advent of AI in their businesses. It must be noted that AI literacy may be required of employees at any point in their career trajectories, which highlights that AI literacy is very relevant for lifelong learning in India.

It must be noted that AI literacy may be required of employees at any point in their career trajectories, which highlights that AI literacy is very relevant for lifelong learning in India.

A search for 'artificial intelligence' and 'India' on 25 April 2022 on three job portals – Naukri,[36] Indeed[37] and MonsterIndia[38] – produced 22,189, 11,479 and 3,587 results respectively, thus demonstrating that AI skills are indeed sought-after by employers in India.

Table 8 and Table 9 show (in descending order of the number of results) the required education, industry and role that Naukri and MonsterIndia specified, and, additionally, the department and company type that Naukri identified.

TABLE 8
Categorization of AI vacancies on the job portal Naukri.com

Education	Industry	Department	Company type	Role
Any graduate	IT services and consulting	Engineering (software and quality assurance)	Foreign multinational corporation	Software development
Any postgraduate	Recruitment/staffing	Data science and analytics	Corporate	Business intelligence and analytics
B. Tech./B.E.	Business process outsourcing/call centre	Customer success, service and operations	Indian multinational corporation	Database administrator/ data warehousing
Postgraduate degree not required	Banking	Sales and business development	Unicorn	Data science and ML
M.B.A./P.G.D.M.	Internet	Finance and accounting	Start-up	Voice/blended
M.Tech.	Software programming	Banking, financial services, insurance, investment and trading	Government/public sector undertaking	Business Development/ pre-sales operations
B.Sc.	Financial services	Consulting		IT consulting
M.C.A.	Insurance	Marketing		Pharmaceuticals
B.C.A.	Analytics/knowledge process outsourcing/ research	Research and development		Other
M.S./M.Sc.	Electronic components	IT and information security		

Source: Naukri.com

TABLE 9
Categorization of AI vacancies on the job portal MonsterIndia.com

Education	Industry	Role
B.Tech./B.E.	IT/computers – software and semiconductors	Software engineer
Aviation	Internet/e-commerce	Team leader/technical leader
M.C.A.	IT/computers – hardware and networking	Research and development engineer
B.C.A.	Banking/accounting/financial services	Application engineer
M.Sc.	Courier/freight/transportation	IT application designer specialist
Ph.D.	Telecom	Software developer
B.Sc.	Recruitment/staffing/recruitment process outsourcing	Hardware design engineer
B.A.	Pharmaceuticals	Project leader/project manager
Diploma	Hospitals/healthcare/diagnostics	Analytics/business intelligence

Source: MonsterIndia.com

36 https://www.naukri.com/

37 https://in.indeed.com/

38 https://www. monsterindia.com/

CASE STUDY 2

AI-supported anticipation of required skills in the Indian labour market
Mapping and matching of skills

Many economies often face the complex challenge of securing the right number of human resources with the right skills at the right time and place. When this is not possible, either positions cannot be filled or there is unemployment, both undesirable situations. A report by the International Labour Organization (ILO) (2020) describes how AI-supported big data analytics (see 'Big data', Chapter 4) can be used to anticipate skills required by the labour market better and faster.

With the established practice of publishing job vacancies online, the internet has become a reliable source of data on current skills in demand and an indicator of future trends, as surmised from job descriptions and advertisements. Moreover, this information is available in real time and at no cost. Mezzanzanica and Mercorio (2019) have developed a methodology for turning this big data into labour market intelligence by using AI. First, Mezzanzanica and Mercorio produced a classification of job vacancies over a standard taxonomy of occupations and skills. Then, a machine learning algorithm was trained to classify a database of over 60,000 job vacancies, and to assign an occupation code to each job vacancy. In general, AI algorithms search for patterns of interest, which, in this case, are patterns that identify potentially emerging occupations and the skills required for these new professions. Such valuable labour market intelligence, available at an early stage, could allow educational ministries and institutions, as well as school graduates, to take appropriate actions: the former to potentially establish pertinent curricula and courses, and the latter to consider pursuing these subjects and courses.

LinkedIn[i] has one of the largest skill databases in the world. It is available in real time because members update their profiles regularly, and it is very granular since it is broken down by location, industry and function. Additionally, historical data is accessible too. The ILO analysed LinkedIn's Economic Graph[ii] for India with a focus on the following four themes: career pathways, AI and emerging technologies,

entrepreneurship ecosystems, and global economic integration. What follows is a summary of what the analysis revealed (ILO, 2020):[iii]

- The top position in terms of volume of hiring in India is that of software engineer. Aside from technology-related roles, business analysts and business development managers are also sought-after in the Indian labour market.

- Artificial Intelligence-related positions dominate the top five emerging jobs, as illustrated in Figure 6.

- The most sought-after tech skills are in SQL, Java and C programming languages, while team management and leadership are the soft skills most in demand.

- Overall, twice as many men as women have reached leadership positions in their careers. Moreover, at the global level, only 22 per cent of AI professionals are women, despite being as skilled as men in the field.

One-third of Indians moving to another country for work reasons migrate to the United States, followed by the United Arab Emirates, Canada, the United Kingdom and Australia. These destinations take in almost 70 per cent of economic migrants from India.[iv]

These insights provide important information for policy-makers in India, including the importance of considering adapting curricula to teach skills that are relevant to emerging jobs and addressing undesirable gender gaps (see also Chapter 3: AI literacy in India).

---

[i] https://www.linkedin.com

[ii] https://economicgraphchallenge.linkedin.com/

[iii] See also: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/presentation/wcms_735377.pdf

[iv] As this analysis is based on LinkedIn data, it does not include migrant workers from India who do not have a LinkedIn profile.

The AI positions on these portals required exclusively technical skills, such as programming languages and environments. Yet, as outlined above, AI literacy comprises both a technological and a human dimension. Although scholars and concerned organizations have advocated that the human dimension of AI literacy is indispensable, the data collected from the job portals above reveal no trace that such characteristics are required by the corporate sector and other employers in India. This shortcoming should be remedied, especially since the application of AI in various industries such as healthcare and pharmaceuticals is subject to serious ethical considerations (see, for example, Saheb et al., 2021).

While its human dimension should always complement technical AI skills, there should also be accompanying positions, at the technical and mangerial levels, that require robust knowledge of AI ethics, particularly for professionals who are likely to formulate and implement AI policies in India (see Chapter 5: Challenges for India) and who may themselves become teachers of AI ethics.

Artificial Intelligence in the National Education Policy 2020

The National Education Policy (NEP) was launched by the Ministry of Education (2020a) on 29 July 2020 to initiate reforms in schools and higher education in India, as deemed necessary for the changing times. The NEP has five foundational pillars: access, equity, quality, affordability and accountability. It also emphasizes the integration of AI in education, acknowledging that 'India must also take the lead in preparing professionals in cutting-edge areas that are fast gaining prominence, such as Artificial Intelligence (AI), 3-D machining, big data analysis, and machine learning, in addition to genomic studies, biotechnology, nanotechnology, neuroscience, with important applications to health, environment, and sustainable living that will be woven into undergraduate education for enhancing the employability of the youth' (p. 51). The NEP highlights several important areas in which the application of AI is mentioned. It recommends introducing courses related to AI at all levels of education to develop the skills required to meet the current demands of industry. In this regard, the policy recommends introducing computational thinking (CT) at a foundational stage of children's education, so that India plays a leadership role in the fields of Artificial Intelligence, machine learning and data science, among others. Computational thinking will involve puzzles and game-based learning (i.e. game elements for learning purposes) in the early stage, and coding will be introduced in the middle stage.

Below: India's National Education Policy 2020 highlights the importance of Artificial Intelligence and integrates AI education at all levels.
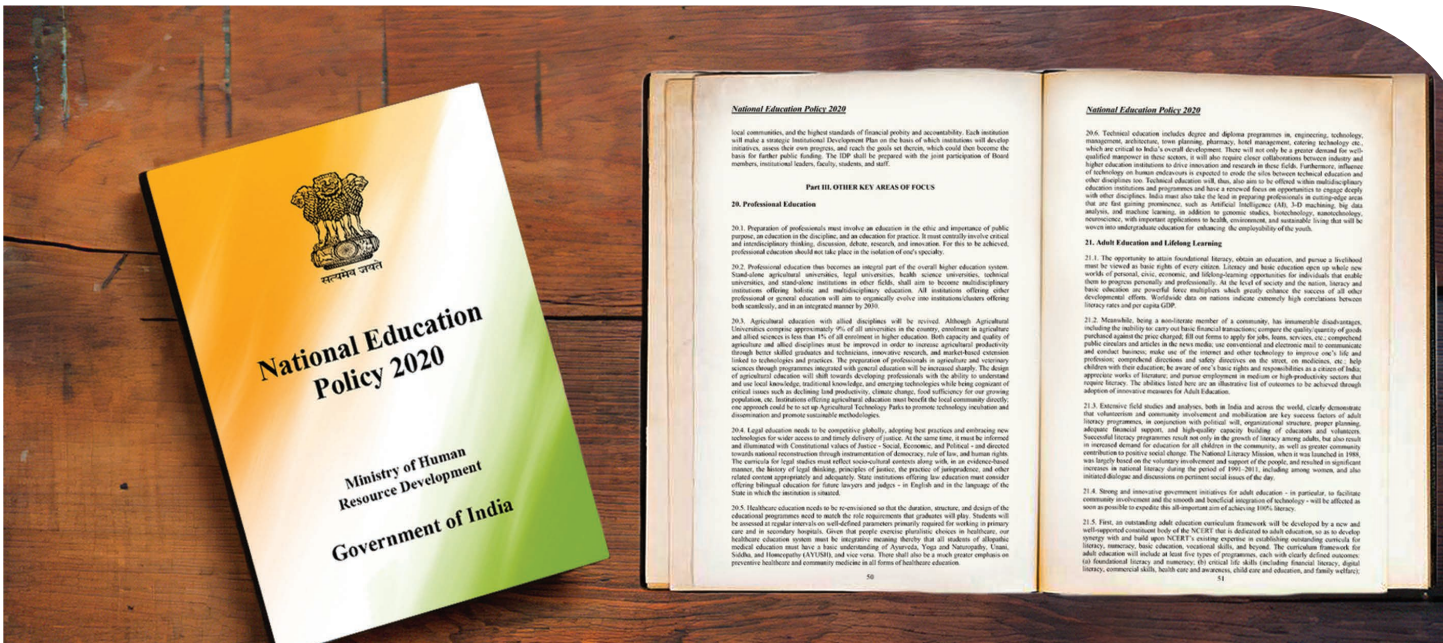
Above: A coding class in progress. Modern Public School, Delhi, India.

The NEP advocates the development of hardware and software that use Artificial Intelligence, machine learning, learning analytics, big data, blockchain, smart boards, adaptive systems, etc. to improve students' learning and to identify their learning paths.

It goes on to advocate for developing AI-based software to track students through their years in school, based on their learning data, to provide information about students' strengths, weaknesses and areas of interest, and thus help students make decisions about the careers they choose. The NEP plans for Higher Education Institutions (HEIs) to offer postgraduate and Ph.D. programmes in interdisciplinary domains that include machine learning and professional areas like healthcare, agriculture and law. SWAYAM, a Government of India programme designed to achieve access, equity and quality in education, will use its platforms to bridge the digital divide and disseminate these online courses for rapid adoption. Higher Education Institutions will also play an important role in offering training in data annotation, image classification and speech processing through vocational programmes. A National Educational Technology Forum is being set up by the Ministry of Education to enhance learning, assessment, planning and administration for both school and higher education, in which AI will play an important role in making data-driven decisions.

The NEP also highlights the importance of ethics in the development and deployment of AI-based technologies. Issues of data privacy, data protection, law and standards of data handling have been addressed in the current policy. In the union budget for 2021/22, the Government of India allocated INR 500 billion over five years to set up a National Research Foundation (NRF). The main aim of the NRF is to establish a strong research ecosystem in Indian universities, colleges and institutions, and promote research and development on identified thrust areas relevant to national priorities without duplication of effort and expenditure. The NRF will focus on three approaches with regard to AI:

❶ Advance core research in AI.

❷ Encourage application-based research in AI.

❸ Promote international collaboration in the areas of healthcare, agriculture and climate change using AI.

INR **500** billion
was allocated in the union budget for 2021/22 by the Government of India over five years to set up a National Research Foundation (NRF)

NRF
aims to establish a strong research ecosystem in Indian universities, colleges and institutions, and promote research and development on identified thrust areas relevant to national priorities without duplication of effort and expenditure

Development and coverage of AI literacy in India

Two prerequisites for AI literacy, at least for its technological dimension, are the knowledge of information and communications technology (ICT) and the availability of necessary infrastructure. Students will not be able to study AI if they are not familiar with at least the basics of ICT. While ICT literacy is beyond the scope of this report, it is noted that NITI Aayog acknowledges that the adoption of technology in education in India is not progressing 'at the pace required', and that the 'adoption of new technologies is still lacking. . . . [which is] often attributed to unwillingness of teachers and students to adopt technology' (NITI Aayog, 2018, p. 35).

K-12

India's national and state governments, along with the private sector, have begun to provide AI education for children across the country. Table 10 indicates that the country's largest education board, Central Board of Secondary Education (CBSE), has added AI to its curriculum, and gives information on efforts to include AI by other educational boards across the country.

TABLE 10

AI covered by the most common boards in the Indian education system

Board	Description	Covered schools
Central Board of Secondary Education (CBSE)	Recent introduction of AI in the curriculum (CBSE and Intel, 2019a, 2019b)	>24,000 schools[39]
Council for the Indian School Certificate Examinations (Indian Certificate for Secondary Education and Indian School Certificate)	The computer science curriculum has a small section on trends in computing and ethical issues, which mentions AI[40]	2,734 schools[41]
International General Certificate of Secondary Education	The ICT curriculum has a small section on emerging technologies, which mentions AI (Cambridge Assessment International Education, 2018)	566 schools[42]
International Baccalaureate	AI is not included in any subject but is sometimes touched upon in Theory of Knowledge (International Baccalaureate Diploma Programme, 2022), a mandatory course within the International Baccalaureate programme	204 schools[43]
State boards	AI has not been included in state curricula yet. However, it has been announced that Madhya Pradesh will be the first state to do so soon. With the support of Microsoft, a course on AI spanning nearly 240 hours will be introduced in classes above Grade 8 across 53 selected schools.[44]	

Source: Compiled by authors

India's national and state governments, along with the private sector, have begun to provide AI education for children across the country.

[39] https://www.cbse.gov.in/cbsenew/Affiliation.html

[40] https://www.cisce.org/pdf/ISC-Class-XII-Syllabus-2020/25.%20ISC%20Computer%20Science.pdf

[41] https://www.cisce.org/locate-search.aspx?country=0&state= 0&dist=0&city=0&location =&schooltype=&cve=&isc =&icse=&schoolclassi= &school=&search=locate

[42] https://www.cambridgeinternational.org/why-choose-us/find-a-cambridge-school/?Location=India

[43] https://www.ibo.org/about-the-ib/the-ib-by-country/i/india/

[44] https://indianexpress.com/article/education/mp-to-introduce-ai-as-a-subject-from-class-8-ropes-in-microsoft-7845098/

Joint collaboration between Intel and CBSE to promote AI
AI Literacy

n 2020, the Central Board of Secondary Education (CBSE) signed a Memorandum of Understanding (MoU) with Intel to develop an AI curriculum framework for Grades 8, 9 and 10. This curriculum aimed to train 100,000 students with AI-readiness skills and included the effective use of AI to solve local and global challenges.[i] The syllabus consisted of 112 hours divided into 5 sections: (1) introduction to AI; (2) AI project cycle; (3) neural networks; (4) introduction to Python computer programming language; and (5) co-curricular skills.[ii]

In 2021, CBSE collaborated with Intel to launch an initiative called the AI Student Community (AISC).[iii] Following the framework of the National Education Policy (NEP) 2020, the AISC focused on preparing a workforce for economic development using AI and the development of technical skills such as data analysis and computational thinking. The AISC organizes webinars by Intel's AI-certified coaches and experts, as well as boot camps and hackathons, for students. In addition, the AISC provides opportunities for students to access curated audiovisual learning resources related to AI.[iv]

In 2022, Intel partnered with CBSE to launch the 'AI for All' initiative to create a basic understanding of AI among the general public.[v] AI for All is a four-hour self-paced course available in eleven Indian languages and accessible to

visually impaired learners.[vi] The course is divided into two sections:

- AI Awareness (1.5 hours), which includes a basic understanding of AI and of misconceptions about AI and its application.
- AI Appreciation (2.5 hours), which involves understanding the key domains of AI, the impact of AI across different industries and the principles of responsible AI and AI ethics.[vii]

[i] https://timesofindia.indiatimes.com/home/education/news/intel-joins-cbse-to-empower-1-lakh-indian-students-in-ai/articleshow/74519113.cms

[ii] https://cbseacademic.nic.in/ai.html

[iii] https://www.hindustantimes.com/ht-school/cbse-joins-hands-with-intel-to-launch-ai-student-community-101615561145212.html

[iv] https://aistudent.community/learningResources

[v] https://www.thehindu.com/sci-tech/technology/intel-launches-ai-for-all-initiative-in-partnership-with-cbse/article35623492.ece

[vi] https://www.intel.com/content/www/us/en/newsroom/news/intel-cbse-launch-ai-for-all-india.html#gs.5peyl0

[vii] https://ai-for-all.in/#/home?ref=CBSE

Since 2019, with support from IBM, Intel and Microsoft, CBSE, which covers secondary education at over 24,000 schools, has taken the innovative step of introducing AI as a subject, using the slogan 'to make India's next generation "AI ready"' (CBSE and Intel, 2019a and 2019b; see Case Study 3). The curriculum includes, for example, an introduction to AI, the AI project cycle and neural networks, and an introduction to the programming language Python.

Teachers are being trained for a twin initiative that involves the introduction of AI as an elective subject in Grades 8, 9 and 10 and also the integration of AI with other disciplines. In 2020, CBSE, in collaboration with Intel, also conducted capacity-building of teachers teaching AI to Grade 9.[45]

At the same time, the initiative stresses that AI is not a standalone field of study, and teachers are encouraged to integrate AI with the following subjects: psychology, philosophy, neurosciences, mathematics, statistics, economics, linguistics, computer science and cognitive sciences (CBSE and Intel, 2019a, 2019b).

Additionally, AI ethics is covered in Grades 1 to 12 with the aim of sensitizing all age groups to this subject through simulations, role playing, discussions and debates. For example, one activity recommended to create ethics awareness is a role-playing game in which students act as major stakeholders who must decide the ethical value of certain scenarios (CBSE and Intel, 2019a, 2019b).

In 2022, the Department of Science and Technology (DST), Government of India, partnered with Intel India to design a 'Building AI Readiness among Young Innovators' programme.[46] The programme aims to democratize access to AI tools and learning tools for students from Grades 6 to 10, enrolled under DST's INSPIRE-Awards MANAK (Million Minds Augmenting National Aspirations and Knowledge) scheme. It aims to build an 'AI-ready generation' and empower the youth with AI technology and social skills in an inclusive way,[47] and will also provide opportunities for students to participate in AI boot camps with AI experts and coaches.[48]

[45] https://cbseacademic.nic.in/web_material/Notifications/2020/70_Notification_2020.pdf

[46] https://dst.gov.in/slider/building-ai-readiness-among-young-innovators

[47] https://inspiremanak.buildingaireadiness.in/home

[48] https://cio.economictimes.indiatimes.com/news/corporate-news/dst-intel-india-join-hands-to-boost-ai-readiness/89942381

Another Indian initiative is 'AI For All', a self-learning online programme designed to raise public awareness about AI. It aims to demystify AI for people from all walks of life. The Education Department of the Government of Tripura has joined hands with Intel to popularize 'AI For All' in government schools across the state.[49]

The Atal Tinkering Labs AI Modules by the Atal Innovation Mission of NITI Aayog (see Case Study 1) also aims to introduce AI to school students.[50] These are K-12 AI curricula with a remarkably high share (35 per cent) devoted to ethics and social impact. Another 30 per cent of the curricula is allocated to AI basics and 35 per cent to understanding, using and developing AI (UNESCO, 2022).

In addition to the Government of India and other institutional actors, the private sector has also found it beneficial and financially rewarding to be involved in AI education, predominantly through online platforms. Examples of online AI courses for children offered by Indian companies are showcased in Table 11.

TABLE 11
Some examples of online AI courses for children offered by Indian companies

Name	Description
DIYA[51]	• Animation and AI
Codevidhya[52]	• AI with Scratch and App Inventor • Python with 3D Games • AI with ML and Data Science

Edufiq[53]	• AI Bundle Pack
	  » Introduction to AI
	  » Programming for AI with JavaScript
	  » Programming for AI with Python

Futolearn[54]	• App Lab • ML • AI Inspire
Mind Champ[55]	• AI

Source: Compiled by authors

Higher education

There are many options in India to study AI towards various advanced degrees. Some examples are listed in Table 12.

TABLE 12
Some examples of Indian institutions offering Bachelor's, Master's or Diploma courses related to AI

Name	Degrees offered
National Institute of Robotics & Artificial Intelligence[56]	Master's programme in AI, Advance Certification in ML, Advance Diploma programme in AI
National Institute of Electronics & Information Technology[57]	Advanced Diploma in AI
DIT University[58]	B.Tech. in computer science and engineering, including a specialized track in AI, ML and robotics
MIT World Peace University[59]	B.Tech. in electronics and communication engineering (AI and ML)
UPES[60]	M.Tech. in computer science and engineering (AI)
Indraprastha Institute of Information Technology Delhi[61]	B.Tech. in computer science and AI programme
Indian Institute of Technology (IIT) Hyderabad[62]	M.Tech., Department of AI
Amrita Vishwa Vidyapeetham[63]	B.Tech. in robotics and AI

Source: Compiled by authors

---

[49] https://vidyajyotischools.com/

[50] https://aim.gov.in/atl.php

[51] https://www.diyalabs.com/

[52] https://codevidhya.com/

[53] https://edufiq.com/

[54] https://futolearn.com/

[55] https://www.mindchamp.in/

[56] https://nira.ac.in/artificial-intelligence-program.php

[57] https://nielit.gov.in/calicut/course- calendar?coursecode= SW800

[58] https://www.dituniversity.edu.in/ug-courses/btech-computer-science-and-engineering#computer-science1

[59] https://mitwpu.edu.in/campuslife/b-tech-electronics-communication-engineering-artificial-intelligence-and-machine-learning

[60] https://www.upes.ac.in/course/m-tech-computer-science-and-engineering

[61] https://www.iiitd.ac.in/academics/btech

[62] https://ai.iith.ac.in/

[63] https://amrita.edu/program/b-tech-bachelor-of-technology-in-robotics-and-artificial-intelligence/

There are also several research centres for AI in India, of which some examples are listed below:

- The Centre for Excellence in Artificial Intelligence at the Indian Institute of Technology (IIT) Kharagpur.

- The Centre for Artificial Intelligence & Robotics at the Defence Research and Development Organisation (DRDO), Bengaluru.

- The Robert Bosch Centre for Data Science and AI at IIT Madras.

- The Artificial Intelligence Group at the Indian Institute of Science (IISc), Bengaluru.

- INAI, an applied AI research centre at the International Institute of Information Technology, Hyderabad (IIIT-H).

- The Department of Artificial Intelligence at IIT Hyderabad.

- AMMACHI Labs (Amrita Multi Modal Applications and Human Computer Interaction) at Amrita University, Vallikavu, Kerala.

- The Center for Societal Impact through Cloud and Artificial Intelligence at Microsoft Research Lab, Bengaluru.

- The Yardi School of Artificial Intelligence at IIT Delhi.

- The Machine Intelligence and Robotics Center at IIIT Bangalore.

- Center for Computational Engineering and Networking at Amrita Vishwa Vidyapeetham

Lifelong learning

UNESCO places great importance on lifelong learning, particularly through the activities and initiatives implemented by its Institute for Lifelong Learning.[64] To become AI literate at an older age is crucial for several reasons: unlike many other school subjects, the field of Artificial Intelligence has developed dramatically in recent years and after many Indians had finished their regular education. At the same time, there is a consensus that AI will have a major impact on many aspects of life, entailing both opportunities and challenges. To take advantage of the opportunities and to raise due awareness of the challenges, it is critical that large sections of society gain AI literacy. This is especially crucial for people whose jobs were initially unrelated to AI, but now require knowledge of AI. This includes teachers in particular, but also many other professionals as described above.

Table 13 lists some examples of international and Indian online platforms that offer AI courses for lifelong learners and are also applicable to teachers.

TABLE 13

Examples of online platforms offering AI courses for lifelong learners and teachers

International	Indian private sector	Government of India
Elements of AI[65]	Future Skills Prime	AI for Everyone by IndiaAI, the national AI portal of India[66]
OKAI[67]	VEPSUN[68]	Future Skills Prime[69]
AI4ALL[70]	Ethnus[71]	SWAYAM[72]
Coursera[73]	Skillup[74]	DIKSHA[75]
edX[76]	'Ai for All' by Intel and the MoE, Government of India[77]	
Alison[78]		
Udemy[79]		
Harvard Online Courses[80]		
MIT OpenCourseWare[81]		

Source: Compiled by authors

There have also been specific one-time programmes and initiatives to achieve AI literacy for teachers in India, of which some examples are listed below along with the year in which they took place:

- Online Training Programme for AI Teachers under The Global Teachers Academy for Digital Technologies by CBSE and IBM (2021).

- Online Training on Artificial Intelligence for Education by CIET-NCERT (2021).

- Training Teachers for Artificial Intelligence in Schools by Machine Intelligence Research Labs and HSNC University (2020).

- Short-term course on Artificial Intelligence for Education by the MIT Centre for Future Skills Excellence (2021).

64 https://uil.unesco.org/

65 https://www.elementsofai.com/

66 https://d33y28zb5d7ry2.cloudfront.net/public/docs/AI+for+Everyone+Booklet+-+compact+.pdf

67 https://okai.brown.edu/

68 https://www.vepsun.in/index.php

69 https://futureskillsprime.in/

70 https://ai-4-all.org/

71 https://ethnus.com/

72 https://swayam.gov.in/nc_details/NPTEL

73 https://www.coursera.org/in

74 https://in.skillup.online/

75 https://diksha.gov.in/#

76 https://www.edx.org/

77 https://indiaai.gov.in/news/ministry-of-education-launches-ai-for-all-initiative-in-collaboration-with-cbse-and-intel

78 https://alison.com/

79 https://www.udemy.com/

80 https://pll.harvard.edu/

81 https://ocw.mit.edu/

National Digital Education Architecture – Vidya Samiksha Kendra
(NDEAR-VSK)
School management

Historically, it has been proven that data collection, monitoring, analysis and correlation are essentially meant to enable taking timely actions to implement welfare schemes. Various initiatives of the Ministry of Education are currently working in silos, like the Unified District Information System for Education (UDISE), the Student Database, the National Assessment Survey, the National Initiative for Proficiency in Reading with Understanding and Numeracy (NIPUN Bharat Mission), the Teacher Database, the Digital Infrastructure for Knowledge Sharing (DIKSHA), the National Initiative for School Heads' and Teachers' Holistic Advancement (NISHTHA), etc. However, running multiple schemes brings challenges of effective implementation due to a lack of:

1 Visibility to stakeholders: that is, 'Ability to See' what's going on in almost real time.

2 Insights about what's happening: that is, 'Ability to Make Sense' of what's working / what's not.

3 Coordination in driving improvements: that is, 'Ability to Amplify Actions' through timely, coordinated efforts based on data and insights.

Keeping this in mind, Indian states and union territories were advised to establish a central system called the Vidya Samiksha Kendra (VSK) at the state level to track student enrolment, progress in their learning levels, Out of School Children mainstreamed, textbook delivery, support required by teachers and schools, etc.

The VSK is aimed at leveraging data and technology to bring a big leap in learning outcomes. This will include the data of over:

15 million schools

9.6 million teachers

260 million students

The VSK will analyse theses data meaningfully using big data analysis, Artificial Intelligence and machine learning to enhance the overall monitoring of the education system and thereby improve learning outcomes.

India's National Education Policy 2020 gives great importance to the need to invest in the creation of public digital infrastructure in the education sector, which is open, interoperable, evolvable and can be used by multiple platforms and point solutions to solve India's scale, diversity, complexity and device penetration issues (as per Section 24.4 (b) 'Digital infrastructure').

Understanding the above challenges, the National Digital Education Architecture (NDEAR)-compliant AI-enabled VSK has been set up at the Central Institute of Educational Technology (CIET-NCERT) campus in New Delhi, India. This national surveillance system aims to function as an institutional avenue that enables integrated and shared 'seeing' for amplifying data-based decision-making to drive action by key stakeholders for the success of their programmes.

The beneficiaries of NDEAR-VSK include schools, teachers, students and administrators across the country. Its implementing bodies include the NCERT, SCERTs/SIEs and Samagra Shiksha in the states and union territories, other autonomous bodies, etc.

SOME OF THE MAIN OBJECTIVES OF NDEAR-VSK

- To monitor the real-time status of various projects/activities under the ambit of Samagra Shiksha.

- To keep track of enrolled students, including learning outcomes and drop-outs, and of support required by teachers and schools, etc.

- To monitor and track field-level academic and non-academic activities at the state level and also empower administrators and teachers in the field to take data-driven decisions.

- To identify and analyse improvement areas for decision-making and implementation that need urgent attention.

- To improve the academic performance of students and to enhance the accountability of teachers in schools and the effective utilization of available resources.

- To set up centralized help desks for grievance redressal mechanisms for stakeholders of school ecosystems.

- To develop centralized dashboards providing real-time performance indicators of schools.

- To increase accountability among all field-level staff/administrators and monitor the real-time status of various project components/activities under the ambit of school education.

SOME OF THE DESIRED OUTCOMES OF NDEAR-VSK

- Monitoring of access, enrolment, drop-out rate, retention, completion and achievement.

- Child-wise tracking of achievements and assessments.

- Real-time attendance-monitoring of students and teachers.

- Tracking the distribution of incentives like scholarships, uniforms, free textbooks, etc.

- State-level centralized monitoring mechanisms in the form of Command and Control Centres (CCC) for monitoring, tracking, taking feedback and providing support to all major field-level staff/activities of the school education system.

- Real-time data integration and analysis of various existing Samagra Shiksha applications for a centralized monitoring dashboard along with the integration of data-analysis-based call management utility and reporting.

- Real-time data that improves school management and governance by timely interventions, streamlining processes, creating transparency and driving accountability through channelized escalations to field-level academic and non-academic staff and timely actions.

- Quick delivery of alerts, notifications and news with minimal failure rate among field-level staff, headmasters, teachers and parents.

- To motivate, encourage and facilitate teachers by sending actionable and continuous tips on best practices in pedagogy and teaching in classes.

Source: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1843168 and Central Institute of Educational Technology, NCERT

Above: Students test an AI-based mask-detection program that they made. Modern Public School, Delhi, India.

Opposite page: A student developed a forest tracker application, which uses image detection to track trees as they are cut or planted. Modern Public School, Delhi, India.

61%

more women used
the internet in India
between 2020 and 2022

85%

of adolescent girls did
not have a laptop or a
computer at home
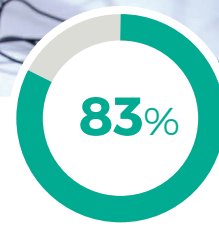
83%

of adolescent girls had access
to a computer lab facility for
less than an hour a week

Above: Students work
on an AI-based program
to recognize faces and
objects. Modern Public
School, Delhi, India.

82 The survey had 4,100
respondents. The
respondents consisted
of 2,220 adolescent
girls (aged 12-20 years),
630 family members
of adolescent girls
(aged 25-70 years), 617
teachers and educators
(primary, secondary
and higher secondary),
and 633 representatives
of community
organizations
(government employees,
NGO workers, private
employees and self-
employed workers).

Special focus: girls and women

UNESCO, in cooperation with the Organisation for
Economic Co-operation and Development (OECD)
and the Inter-American Development Bank (IDB),
has analysed the effects of AI on the working lives
of women globally (UNESCO et al., 2022). Since
women tend to be in a relatively more precarious
situation than men in terms of job security and
earnings, and have greater obligations towards
child- and elder-care, it is crucial that AI be
harnessed to narrow this gap, especially while
there are risks that it may widen it instead. One
of the reasons for such risks is that women
are relatively less engaged than men in STEM
disciplines, which are related to AI and provide
a foundation for AI literacy. Since AI is likely to
be disruptive of the labour market, programmes
supporting the reskilling and upskilling of women
are critical. Such initiatives should be supported
widely by governments, non-governmental
organization (NGOs), academia, trade unions and
the private sector (UNESCO et al., 2022).

Statistics regarding women and girls in India and
their chances of becoming AI literate are indeed
sobering. In 2017, less than one-third of internet
users in India were women (UNICEF, 2017). Given
its large population, this means that India alone
accounts for almost 50 per cent of the digital
divide globally (DEF and Centre for Catalyzing
Change, 2021). However, Nielsen (2022) measured
that the number of female internet users in India

grew by 61 per cent between 2020 and 2022,
while male internet users grew by only 24 per
cent in those two years.

In 2019, 61 per cent of women in India relied on
mobile phones as their sole or primary means
of internet access (Rowntree, 2019). A survey
conducted by the Centre for Catalyzing Change
and the Digital Empowerment Foundation
(DEF) to understand the digital gap that India's
adolescent girls are facing revealed that 57.6
per cent of adolescent girls feel that their male
classmates get easier access to the digital
facilities in their schools and colleges (DEF and
Centre for Catalyzing Change, 2021).[82] Moreover,
85 per cent of adolescent girls did not have a
laptop or a computer at home, and 83 per cent
of adolescent girls had access to a computer lab
facility for less than an hour a week.

Traditional gender roles and biases also play
a major role in limiting girls' access to digital
tools. For example, parents responding to the
survey offered the following justifications for not
allowing their daughters to access the internet
or limiting their daughters' time online : 'not
safe', 'unhealthy distraction', 'she will misuse it'.
Instead, in 2022, girls and women in India spent
up to 352 minutes (around 6 hours) daily working
on domestic tasks, which is approximately 577
per cent more than men, a massive obstacle
to e-learning and education in general (OECD,
2022).

54

22%

of India's AI talent pool in 2018, which was the second-largest in the world, comprised women

In terms of skills, only 26 per cent of adolescent girls knew how to use offline apps (clock or calculator), 38 per cent did not know how to use MS apps (Word, PowerPoint, etc.), while 16 per cent did not know anything about computers (DEF and Centre for Catalyzing Change, 2021). Since the above metrics constitute preconditions for AI literacy, girls and women who do not meet them are also, ipso facto, excluded from obtaining AI skills.

Another related metric is that the number of female schoolteachers in India is on the rise, which is good news in and of itself, and yet, unfortunately, may further hamper overall AI literacy. While there are now more female teachers than male ones in total at the primary level, the ratio is reversed at higher levels (Ministry of Education, 2021b; UNESCO, 2021a). Ideally, these female teachers should have the necessary AI (and STEM) skills to train the next generation in India, but this is often not the case because of the circumstances outlined above, which then repeats the vicious circle of reduced AI literacy and proficiency among girls and women.

In an interesting turn of events, although some metrics related to female AI literacy in India are poor, Indian women rank highly in several AI-related statistics globally. In 2018, India had the world's second-largest AI talent pool, of which 22 per cent comprised women (World Economic Forum, 2018). While this ratio should improve, many other countries in the study had an even smaller proportion of women in their AI workforces,[83] and the best ratio amongst the countries examined was no more than 28 per cent (in Italy, Singapore and South Africa). In a more recent publication, Indiaai (2021) presents success stories of twenty-one Indian women in AI but notes that less than 30 per cent of employees in the AI industry are female.

India leads the world by far in terms of women with AI skills. This gender skill divide is clear from the OECD.AI live data displayed in Figure 9, which shows the prevalence of women workers with AI skills across countries, as self-reported by LinkedIn[84] users from 2015 to 2020. Each country's score is measured in terms of all the countries' combined average (equal to 1). The graph reveals that women in India are 3.16 times more likely to report having AI skills than is the global average for female employees (OECD.AI, 2021).

In an interesting turn of events, although some metrics related to female AI literacy in India are poor, there are Indian women who rank highly in several AI-related statistics globally.

FIGURE 9
AI skills among women by country (self-reported by LinkedIn users, 2015–2020)

Country	Score
India	3.16
United States	1.77
Republic of Korea	1.26
Singapore	1.09
Average	1
P. R. China	0.86
Canada	0.85
Israel	0.84
France	0.71
Australia	0.68
Switzerland	0.68
Germany	0.68
Sweden	0.62
United Kingdom	0.58
Spain	0.54
Netherlands	0.46
South Africa	0.48
Brazil	0.35
Italy	0.33
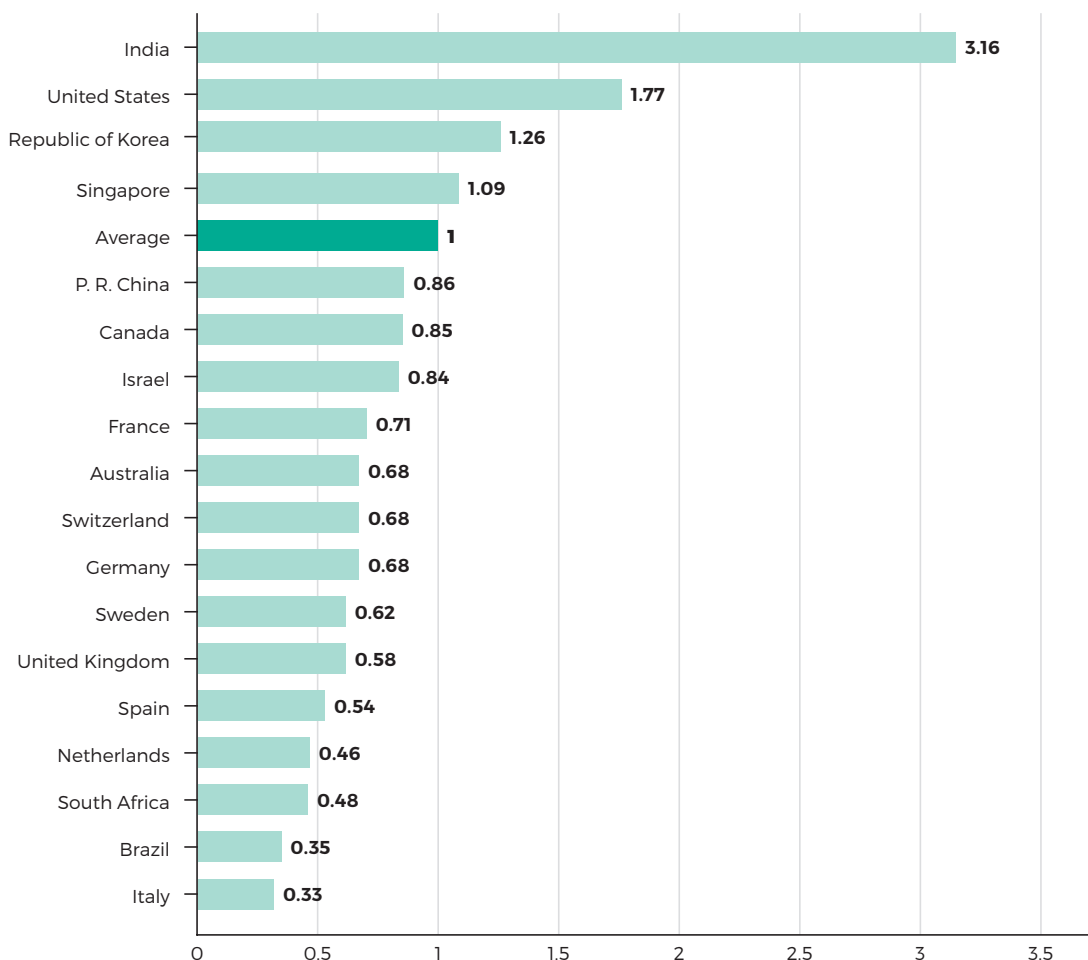
83 For example, Brazil (14%), Mexico (15%) and Germany (16%), among others.

84 https://www.linkedin.com

Another metric in which India leads the world by a wide margin is the share of women with scientific publications related to AI. As Figure 10 shows, almost one-third of all Indian authors of scientific publications dealing with AI are female, while globally the share of women credited with AI-related scientific publications in the Scopus[85] database is below 20 per cent.

FIGURE 10

Percentage of AI publications in Scopus with at least one female author by country and over time

Legend:
- India
- France
- United States
- Canada
- Germany
- P. R. China

Source: https://oecd.ai/en/data?selectedArea=ai-research&selectedVisualization=share-of-women-in-scientific-publications-by-country-2
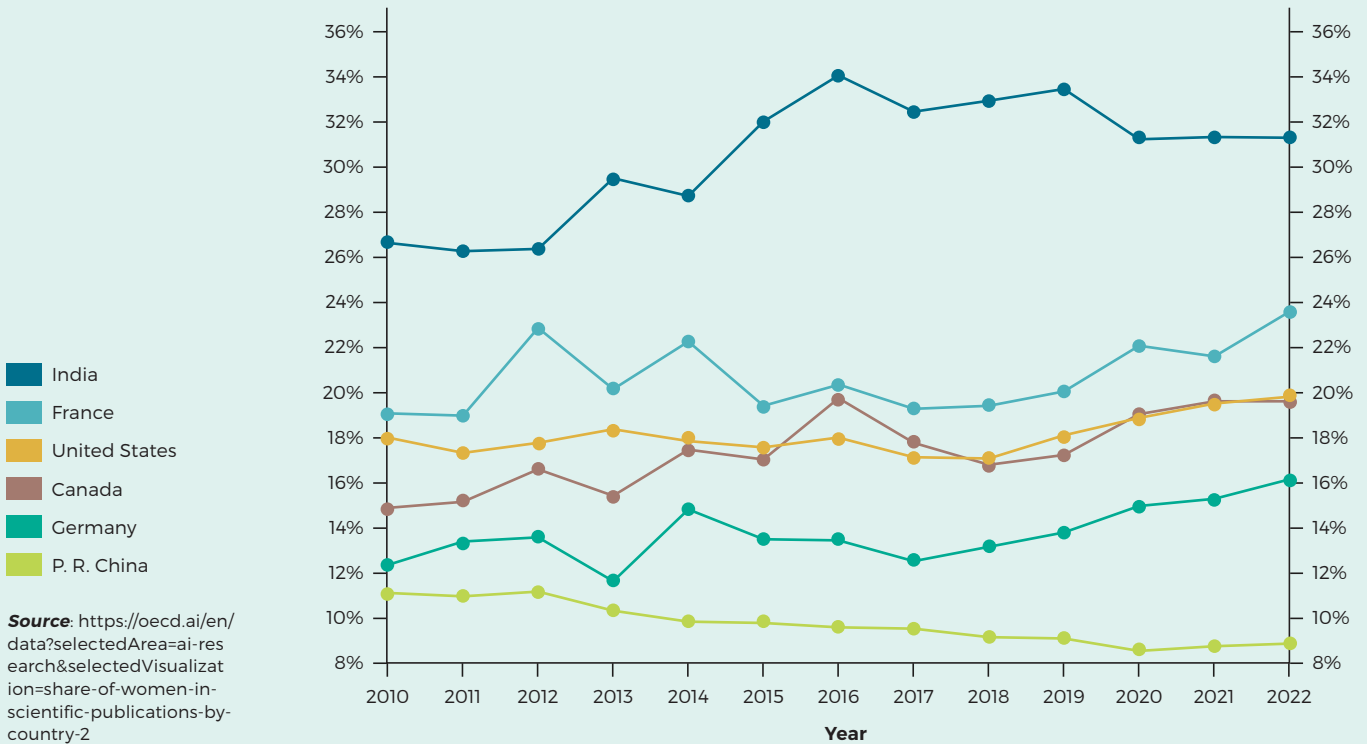
In summary, the metrics above indicate that while many girls and women in India face challenges in getting the chance to become AI literate, those Indian girls and women who overcome these difficulties and get to work in the field do achieve professional success.

BOX 3

Some good practices to promote AI literacy among girls and women

GIRLS IN AI INDIA 2021 HACKATHON

Coding and More, together with Teens in AI, hosted the first global AI hackathon for teenagers in India to celebrate International Women's Day on 8 March 2021.[i]

STEM FOR GIRLS

An initiative by IBM that aims to improve education and career pathways for 200,000 girls across India by providing skills in computational thinking and coding, digital and AI fluency, future and twenty-first-century skills as well as STEM support.[ii]

TECHSAKSHAM

This programme applies an experiential learning methodology to develop employability skills in the sciences, computer applications, vocational areas and engineering for underserved female students.[iii]

[i] https://codingnmore.com/girls-in-ai-india-2021-hackathon/

[ii] https://www.ibm.org/initiatives/stemforgirls

[iii] https://techsaksham.org/

[85] https://www.elsevier.com/en-in/solutions/scopus

Special focus: disadvantaged socio-economic groups

As argued above for girls and women, it is also crucial that the advent of AI in many aspects of life in India does not increase existing gaps for other disadvantaged socio-economic groups, but is harnessed to narrow these gaps instead. A precondition for achieving this is that all groups in society have an equal chance to gain AI literacy. Disadvantaged socio-economic groups in India are very diverse, and their dimensions include rural populations, differently abled people and linguistic minorities.

Various products developed by the private sector to study AI are usually unaffordable for large sections of Indian society because catering to these groups is not economically advantageous for the private sector. Given

that disadvantaged socio-economic groups cannot afford currently available private sector products, it is necessary that the public sector provide programmes to these groups for them to achieve AI literacy. While some of the online courses mentioned above are technically open for all and are relatively convenient for mobility-impaired students, they may exclude several other disadvantaged socio-economic groups as they require users to have internet access, to be neither visually nor hearing impaired, and to know English. Apart from internet access, there are AI in Education solutions for these issues being developed to enable inclusive access to education, including AI education, for all socio-economic groups. These are described in Chapter 4: Opportunities for India.

BOX 4

A good practice to promote AI literacy among disadvantaged socio-economic groups

ROBOTEX INDIA

A non-profit organization that brings robotics and AI as well as science, technology, engineering, the arts and mathematics (STEAM) education to government schools in urban, rural and tribal areas, Robotex India organizes India's biggest robotics festival as

well as workshops with themes like 'Girls Who Build Robots', 'Girls Who STEAM', 'Build your First Robot', 'Machine Learning + App Builder', 'Gamification + STEAM', etc. Robotex also runs a 'Robotics Future Skills Labs' in ten schools.[i]

—————————

[i] https://www.robotex-india.in/index.html

Below: Hands-on workshops on reimagining the future were part of the Participatory Artificial Intelligence with Schoolchildren (PAIZ) project. Here, a student visualizes what robots might look like in the future. SKV Chirag Delhi School, New Delhi, India.

Status of AI literacy in India

Some indicators can measure how successfully AI skills are taught. For example, in the *Artificial Intelligence Index Report 2022*, Zhang et al. (2022) present an AI skill penetration metric, defined as the average share of AI skills among the top 50 skills in each occupation, based on self-reported LinkedIn data about skills listed on a member's profile, positions held and the locations of these positions (see Figure 11). For the aggregated data from 2015 to 2021, it turns out that India has the highest relative AI skill penetration rate (3.09 times the global average), followed by the USA (2.24 times the global average) and Germany (1.70 times the global average), which corresponds to the rate for women in India, too (see Figure 9).

FIGURE 11
Relative AI skill penetration rate by country

Country	Rate
India	3.09
United States	2.24
Germany	1.70
P. R. China	1.56
Israel	1.52
Canada	1.41
United Kingdom	1.40
Republic of Korea	1.28
Singapore	1.22
France	1.11
Spain	0.84
Australia	0.77
Switzerland	0.76
Italy	0.74
Sweden	0.60
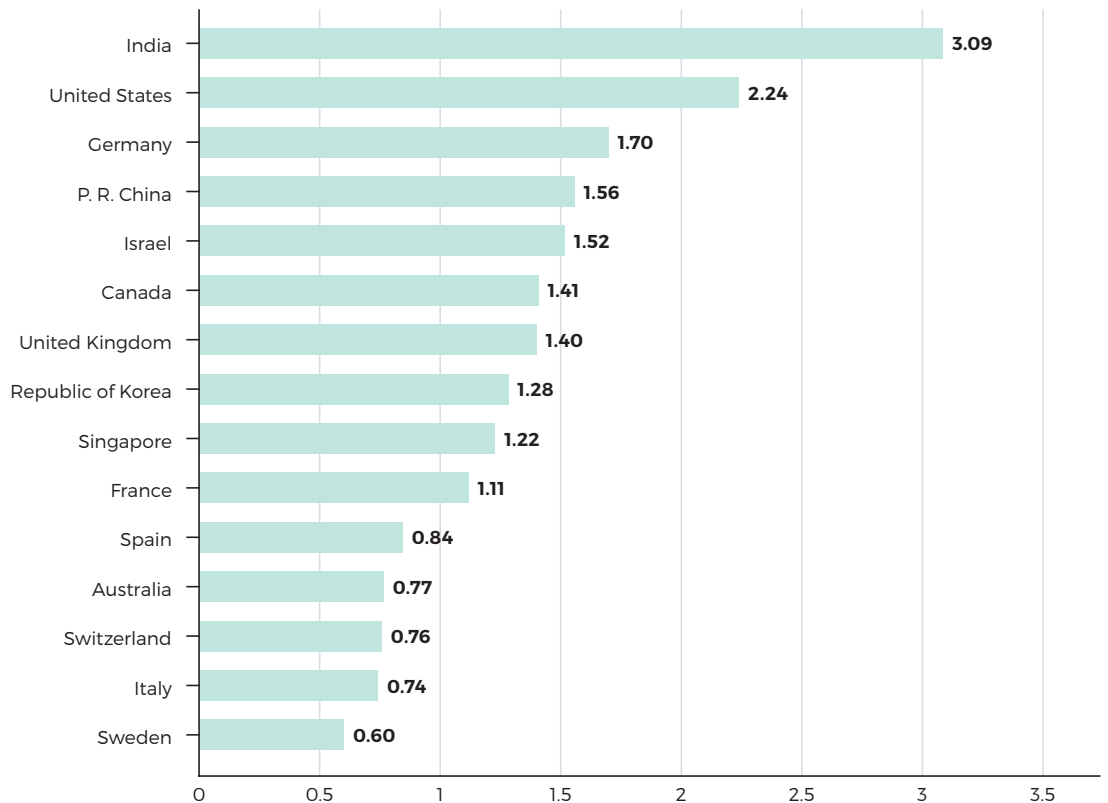
Source: Zhang et al., 2022, p. 149

Moreover, Chahal et al. (2021) report that India is the fourth-largest producer of AI-relevant scholarly papers since 2010. Another metric cited by Chahal et al. is the number of AI patents produced by country, and India finds place among the top ten AI patent-producing countries owing to a significant increase of AI patent applications in India since 2012. Overall, Chahal et al. conclude that there is a large pool of Indians with AI talent, but they stress that only a very small number of doctoral students are working on AI in India and that most of them go overseas, especially to the United States of America. This constitutes a brain drain for the Indian economy and reduces the number of AI lecturers, who are required to teach the future domestic AI workforce (see also Box 5 in Chapter 4 - What can India offer to the world in AI?).

Albeit partly proxy indicators, these metrics demonstrate that India is advanced in terms of AI literacy. However, the issues that pertain to girls and women as well as disadvantaged socio-economic groups require attention. Moreover, the above metrics offer no breakdown of the technological and human dimensions of AI literacy. Although the inclusion of AI ethics in K-12 curricula is a positive step, this chapter ends by stressing, once again, the critical need to study AI's human dimension as an essential requirement for real AI literacy, in India as well as globally.

Opposite page: A student inspects a robotic arm made at his research institute. International Institute of Information Technology, Bengaluru, Karnataka, India.

Summary

AI literacy is becoming highly relevant in India since the AI market is the primary growth driver of the broader IT and data science industry (e.g. Analytics India Magazine and Jigsaw Academy, 2020). Jobs in these fields require AI literacy.

This applies to newcomers in the industry as well as to experienced staff who would need to retrain and update their skills to keep up with rapid progress in AI.

The public policy think tank of the Government of India, NITI Aayog (2018), acknowledges the importance of AI literacy in India and sees it as a national priority. This is also reflected in the National Education Policy 2020, which emphasizes the integration of AI in education (Ministry of Education, 2020a).

AI literacy consists of a technological and a human dimension. The technological dimension concerns data and algorithm literacy, and the human dimension comprises raising awareness about the limitations and risks of AI as well as AI ethics.

The human dimension is often neglected though it is relevant to all individuals who have to deal with AI, which is likely to be everyone in the future.

Globally, India is well advanced in terms of AI literacy, as illustrated, for example, by the fact that India has the world's highest relative AI skill penetration rate (Zhang et al., 2022).

Two issues need attention: often, women and girls as well as other disadvantaged socio-economic groups have fewer opportunities to become AI literate in India, and the human dimension of AI literacy is often overlooked vis-à-vis its technological dimension.
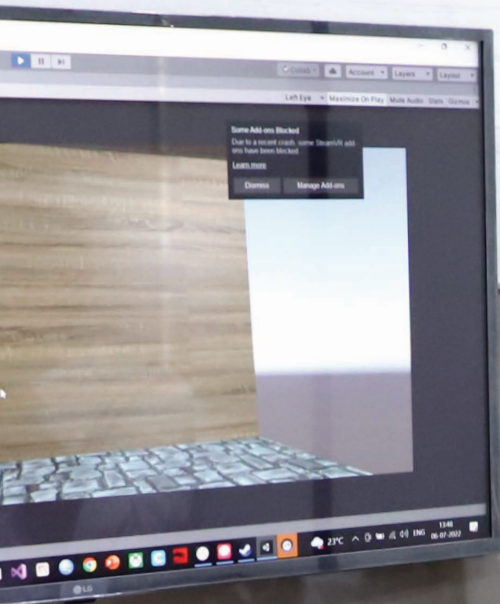
Opportunities for India

AI-powered education tools concern different dimensions of education, such as formal and informal learning, teaching, evaluation, school management as well as mapping and matching of skills. All these dimensions are covered in this chapter, but its focus remains on learning since it is in this field that the most seminal disruptions are expected.

Left: Taking an electroencephalogram (EEG) measurement for interactive metaverse. Indian Institute of Science, Bengaluru, Karnataka, India.

4 Opportunities for India

The inclusion of cutting-edge technologies like AI in Education is ushering waves of change into the design, delivery and continuous improvement of learning methods. AI has begun making inroads into the Indian education landscape, thus bridging the socio-economic and gender divide in the sphere of Indian education. Lee and Chen (2021) have identified two flaws in today's education system: there is a one-size-fits-all approach though every student is different, and quality education is expensive, which often leads to unreasonable student-to-teacher ratios. AI has the potential to fix this: firstly, through personalized learning, and secondly, through automation.

This chapter describes a variety of opportunities for AI-powered education tools in India. As with almost all new technologies, challenges are unavoidable, and these are outlined in the following chapter.

Tracking learning outcomes and assessing competencies

Among the most promising AI in Education applications are automated assessment systems. Already developed before the advent of AI, such systems assess students' exams and assignments and gives score to them just like a teacher would. However, the AI disciplines of natural language processing (NLP) and machine learning (ML) have facilitated significant progress in the quality of these systems. For example, a specific category of these systems is called 'automated essay scoring' and it evaluates writing projects. Automated assessment systems have different features, ranging from providing overall scores and delivering instantaneous individual feedback to offering guidance for improvement. The overall trait they have in common is that they perform a certain task efficiently, namely, the quantification and analysis of learning progress and competencies, an undertaking that is typically very time-consuming for teachers, especially considering, for example, large-scale entrance exams for admission to educational institutions. Given the size of school classes, it is impossible for teachers to constantly quantify of every student's performance, although this is desirable.

Automated assessment systems are important for bridging the gap created by socio-economic inequalities in the Indian education sector, which not only suffers from an acute shortage of teachers but also struggles with the issue of teachers' time being wasted. Automated assessment systems in schools located in remote areas, rural regions and underprivileged urban settlements could free up teachers' time, allowing them to focus on in-classroom activities and on offering personal attention to each student. Additionally, these systems remove human bias and manual errors from assessments and grading, while also providing evaluations of individual students relative to their peers across the city, district or nation. This would be possible through a centralized automated assessment system that possesses training and test datasets from across the nation.

> Automated assessment systems are important for bridging the gap created by socio-economic inequalities in the Indian education sector, which not only suffers from an acute shortage of teachers but also struggles with the issue of teachers' time being wasted.

Opposite page: A policy support system has been evolved to assist policy researchers in the design and evaluation of policies with a particular focus on the Sustainable Development Goals. International Institute of Information Technology, Bengaluru, Karnataka, India.
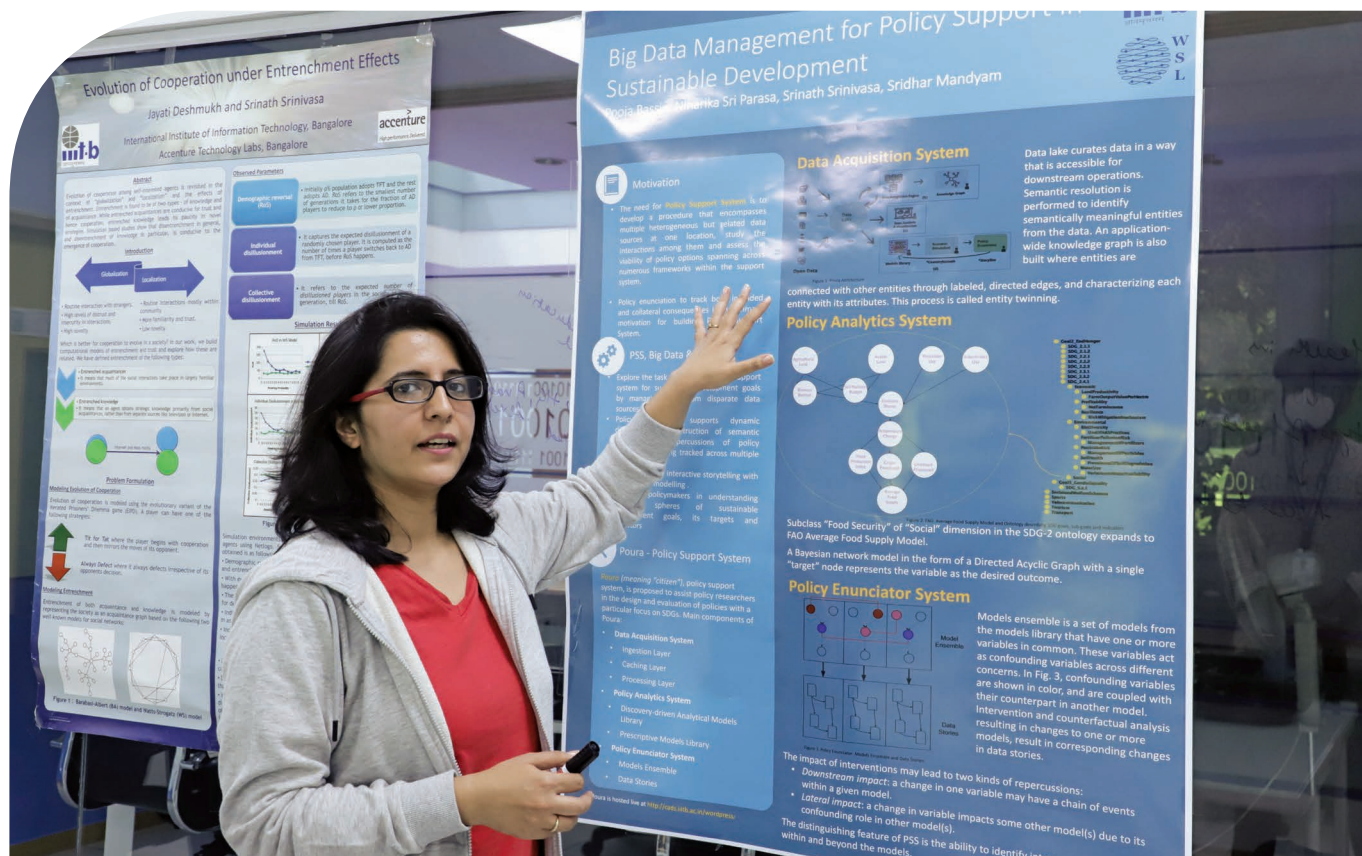
Big data

Educational data mining and learning analytics are pertinent subdisciplines of AI, with the purpose of analysing educational data and generating actionable information, aided by machine learning.

Automated assessment systems rely on data. The more data is available, the better. Big data has been a buzzword for some time, and various sources describe data metaphorically as the fuel for the engine of AI. Technological developments have not only increased the amount of big data significantly, but also the variety and often the real-time availability of such data. Big data is often characterized by the so-called '3Vs': volume (the amount of data), variety (the different types and sources of data) and velocity (the real-time availability of data) (Laney, 2001). These developments have created a hope that big data and AI may help in the achievement of the SDGs (see, for example, Ziesche, 2017), including SDG 4, which relates to education.

The availability of big data spurred a movement called 'quantified self',[86] whose members track a diverse range of data about their lives and their bodies through emerging technologies, often aiming to improve their health and physical performance. This was based on the new insight that the more data we have on ourselves, the better we can analyse our own performance, or detect issues, ideally at an early stage, and, if possible, prevent or fix them. The same reasoning can be applied to educational performances.

As described by Burns (2021), teachers have always used data to give feedback and guidance to students. What transformed this paradigm was the move towards digital data, especially in distance learning environments. Of late, the 3Vs of data are contributing to optimism in the field of education: more and more data about the performance of students has become available in a variety of formats and often in real time. The whole field of AI in Education, and of automated assessment systems in particular, depends on big data.

Educational data mining and learning analytics are pertinent subdisciplines of AI, with the purpose of analysing educational data and generating actionable information, aided by machine learning. In this way, students' performances can be monitored and measured continuously to generate automatic feedback, which includes advice on how they can improve.

Moreover, Luckin et al. (2016) describe how such AI-supported systems, and the wealth of data they analyse, will likely provide new insights on how learning takes place. Not only do these systems analyse students' answers, they also gather data on the underlying processes that lead students to their answers, including the student's emotional state and whether they are confused, bored or frustrated. Managed properly, this new approach to analysing the learning process has the potential to identify hidden patterns and trends.

Predictive analytics

Predictive analytics is another relevant and widely applied subdiscipline of AI, which uses big historical data and machine learning to make predictions about the future by proposing probable scenarios.

As for how predictive learning analytics applies to AI in Education, it means that systems not only give feedback about past learning performances, but go a step further by also providing predictive analyses of how students' performances may develop in the future. To do so, the systems need historical data about the concerned student and about other students, for comparison and analysis. Only then can the systems potentially discover patterns and trends describing how students have developed under certain circumstances. Moreover, big data coupled with predictive analytics can help AI in Education developers improve their products. Again, it can be said that the more data are available to them, the more precise the systems' predictions are expected to be.

As mentioned above, it is not only important to harness large volumes of data, but also to gather data from a variety of sources. For example, Akgun and Greenhow (2021) describe how facial recognition software can be used to capture and monitor students' facial expressions. Such data can be analysed and linked to learning processes to help refine predictive analytics that allow the systems to alert teachers to intervene and support students if required, in a proactive rather than a reactive manner. Technologies using facial recognition, and also voice recognition and sentiment analysis, can measure levels of student engagement and attention spans while also estimating the magnitude of their comprehension and confidence. For even more sophisticated approaches, Molenaar (2021) proposes considering broader learner characteristics, such as self-regulation, emotion and motivation. These are harder to measure but would enhance the range of available data even further, and thus the pool of potentially pertinent parameters to gauge what is enabling or inhibiting learning for a particular student. However, this is also linked to issues of ethics and privacy, which are discussed in more detail in Chapter 5.

Predictive analytics is especially relevant for students who are at risk of failing. With this in mind, researchers are working on early warning systems (probabilistic models based on large amounts of data) that can identify if a student is at such risk at an early stage (see, for example, Aguiar et al., 2015). As alarming as failing is, students dropping out of school is a more pressing issue in India. Fortunately, data analytics driven by machine learning models can help identify predictive patterns behind why students drop out, and also pinpoint students who are at risk of dropping out.

The risk of failing or dropping out could also be linked to the psychological, social, cognitive and physical well-being of a student, which could also be monitored and analysed through AI systems and potentially proactively addressed (UNESCO, 2020). This is one of the strengths of machine learning algorithms: discovering patterns in data from diverse sources that humans would not have detected.

CASE STUDY 5

AI-driven drop-out risk detection system
School management

n 2019, India experimented with an AI system to predict the school drop-out rate in Andhra Pradesh by taking a sample set of over 200,000 students spread across 2,800 public schools in the state.[i] The Government of Andhra Pradesh collaborated with Microsoft to identify probable drop-outs from government-funded schools using machine learning and learning analytics.[ii] Based on students' personal attributes (which include details of gender, age, family income, district of residence, family and regional literacy and academic performance) and other parameters like school infrastructure and teacher skills, the system identified a predictive pattern using an application supported by an Azure ML algorithm.[iii] Three databases were employed to build the data pipeline for the project: UDISE, containing school infrastructure information and data on teachers and their work experience; education assessment data from multiple sources; and socio-economic data from the UIDAI Aadhaar database.[iv]

The AI-based system identified over sixty patterns that helped track potential drop-out students. This information was used to track and counsel these students to prevent their dropping out. In 2018/19, the AI platform identified over 19,500 probable drop-outs in Vishakhapatnam district. Insufficient furniture and lack of toilets were found to be the key factors influencing the students' decisions. Other influencing factors identified through the application were: learning outcomes (57 per cent), infrastructure (31 per cent), transition (from primary to secondary or secondary to high school) (7 per cent), age inappropriateness (4 per cent) and social category (1 per cent).[v]

While this platform is helping administrators reduce the drop-out rate, it is also important to consider AI ethics and user data privacy as the tracking system uses students' personal data to predict patterns of behaviour. UNESCO (2021b) has noted that learning analytics also involve many ethical challenges, including data privacy and anonymity, accuracy, inclusivity, bias, transparency and reproducibility. Therefore, the government and law regulatory agencies need to play an important role in maintaining users' privacy (Himeur et al., 2022).

---

[i] https://indiaai.gov.in/case-study/ai-is-being-used-to-identify-potential-school-dropout-rate-in-andhra-pradesh

[ii] https://timesofindia.indiatimes.com/city/visakhapatnam/govt-ties-up-with-microsoft-to-check-dropouts/articleshow/63863010.cms

[iii] Ibid.

[iv] https://thewire.in/politics/aadhaar-in-andhra-chandrababu-naidu-microsoft-have-a-plan-for-curbing-school-dropouts

[v] https://indiaai.gov.in/case-study/ai-is-being-used-to-identify-potential-school-dropout-rate-in-andhra-pradesh

---

One example of such predictive analytics is the Command and Control Centre in Gujarat, where possibilities of dropping out are predicted by a surveillance system based on 10 billion datasets. The system tracks enrolment, attendance, learning outcomes and drop-out data, among others things, all of which are analysed by an AI software.[87]

Pertinent interventions could take the form of counselling, financial assistance, reskilling of teachers and revamping of school infrastructure. All potential remedial actions should also be analysed by machine learning systems that evaluate their effectiveness, that is, the reduction of drop-out rates, and eventually filter them to other datasets of best practices.

---

[87] https://indianexpress.com/article/cities/ahmedabad/control-centre-2-0-to-predict-students-at-risk-of-dropping-out-7351791/ and https://indianexpress.com/article/explained/explained-gujarat-govts-control-centre-monitor-educational-projects-7875024/

Personalization

Closely linked with AI systems' capability to track learning outcomes and assess competencies is what may be the most beneficial promise of AI in Education, especially for India: personalization. The lack of personalization is a weakness of the prevailing one-size-fits-all education system, which worsens as the pupil-teacher ratio (PTR) increases. This is particularly relevant given India's large classroom sizes.[88] By contrast, personalization means adapting to students' individual strengths, weaknesses, levels of knowledge and speed of learning to help them achieve their full potential. AI could provide a solution by mapping individual learning plans according to the strengths and weaknesses of each student, based on the same kind of data that are used for students' automated assessments.

Lee and Chen (2021, p. 177) describe the process as follows, using the subject of geometry as an example: AI tools 'will deduce a way to teach geometry to make one student learn faster, even though that method may fail on a thousand other students'. In other words, there are various ways to teach a specific skill to someone, but in regular schools only one method is usually presented to all students. However, AI systems could come up with a highly individualized approach based on two types of data: historical data about the concerned student and about similar students from all over the country, and data about the learning methods and materials that worked best for them.

Burns (2021) refers to the term 'curriculum on demand', which comprises digital resources such as text, media, learning activities, assessments and lesson plans that are based on national standards as a whole but can be personalized, like playlists, depending on the real-time analysis of a student's performance.

Intelligent tutoring systems[89]

AI-powered systems for personalized education are also called intelligent tutoring systems (ITS) and have, like other AI systems, received a significant boost from recent improvements in machine and deep learning techniques. An intelligent tutoring system driven by AI presents content in a tailored manner that is adaptive and agile to students' needs, and customizes the learning path for students in real time, based on their levels of comprehension and cognition. Intelligent tutoring systems provide individual guidance, scaffolding and feedback.

This is linked to adaptive curriculum sequencing, which works on the principle of mapping out the knowledge and skills of students to design a customized curriculum for everyone (see, for example, Machado et al., 2021). It requires the school to identify the key macro-concepts they want to teach students within each subject's curriculum, and then break these down to smaller micro-components that make the learning process manageable for the targeted student audience. These individual micro-components are then sequenced to allow students to individually and gradually build their knowledge of the macro-concepts.

The initial step in personalized learning is to equip students with digital technologies that provide educational content on a web-based platform. The entire course material, including video lessons, assessments, discussion forums, virtual simulators and quizzes, has to be made available online. Based on their pace of learning and progress, performance in customized micro-assessments and evaluation in full-scale

[88] See, for example, UNESCO, 2021a, p. 31: 'On the whole, secondary and senior secondary schools have PTRs between 43:1 and 47:1.'

[89] While this section provides the theoretical background for intelligent tutoring systems, their use is illustrated in the best-case scenario at the end of this chapter as well as in the case studies about Mindspark and Chimple.

Left: A teacher shows her student how to use Mindspark, a personalized online learning platform. Hebbagodi Government School, Bengaluru, Karnataka, India.

CASE STUDY 6

AI-powered learning tool: Educational Initiatives' Mindspark
Learning (formal)

n 2007, Educational Initiatives (Ei)[i] launched an AI-powered learning tool called Mindspark, an adaptive personalized online learning platform that helps learners improve their academic skills by providing engaging activities using interactive games based on individual needs. Mindspark can also support learners develop the confidence to solve complex problems and track their progress. Built on a base of pedagogy research on ten years of assessments data, Mindspark has a strong foundation to diagnose and redress misconceptions. As of now, Mindspark receives 2 million data points every day, which allows Ei to tap continuously into what students know and where they are struggling, and to make Mindspark more effective.

The core features of Mindspark include: (1) personalized instructions based on students' academic levels and learning pace; (2) real-time and detailed feedback based on students' responses; and (3) enquiry-based learning to promote critical thinking. In addition, Mindspark provides training modules for teachers, school leaders and government leaders at district and state levels. EdTech Tulna, a partnership between the Educational Technology department at the Indian Institute of Technology (IIT) Bombay and the Central Square Foundation,[ii] evaluated Mindspark based on its content, pedagogical alignment, and technology and design, and gave it good review ratings in all three parameters.[iii]

Muralidharan et al. (2019) conducted an empirical study to measure the impact of Mindspark on students' performance in mathematics and Hindi, with a focus on learners from low-income neighbourhoods in New Delhi. A total of 619 students in post-primary grades participated in the study and were randomly assigned to either a control group of 305 students or an experimental group

of 314 students that had access to Mindspark. The results showed that the students in the experimental group performed significantly better than the control group in mathematics and Hindi in their final assessments.

Although AI-powered learning tools can improve students' learning performance, it is also observed that online learning tools and platforms may expose the learner to the risk of unnecessary, unethical and potentially harmful data processing (UNESCO, 2021b). To address this challenge, the use of blockchain in AI-based tools can promote the development of secure digital tools and platforms for learners (Himeur et al., 2022).[iv]

Mindspark is being used by students in private schools in India and other countries and by government school students in over ten states in India and in South Africa. It is now available in ten vernacular languages, so that children can learn in a language they are familiar with.

A key barrier in this attempt is the lack of trained and supportive teachers who see technology as an aid and not as a threat. With teachers on board, the implementation of Mindspark and similar platforms is likely to be far more effective (Muralidharan et al., 2019).

---

[i] https://www.ei.study/

[ii] https://www.centralsquarefoundation.org/

[iii] https://edtechtulna.org/evaluation-reports/mindspark-math-9-10/

[iv] 'A blockchain is a decentralized ledger of all transactions across a peer-to-peer network. Using this technology, participants can confirm transactions without a need for a central clearing authority. Potential applications can include fund transfers, settling trades, voting and many other issues.' (https://www.pwc.com/us/en/industries/financial-services/fintech/bitcoin-blockchain-cryptocurrency.html)

examinations, a student's cognitive capability can be assessed in real time, as noted in the previous section. Depending on how well a student is learning and building on what was previously learned, the course can recalibrate its speed, the difficulty level of its content and the additional academic support required, on a continuous basis. With time, the system grows more attuned to the individual student's needs and can tailor the learning material to keep the student engaged, thus helping achieve educational outcomes.

An additional benefit of being made available online is that the learning material can be updated easily, according to the latest releases and requirements, unlike physical books, which can become outdated and are expensive and time-consuming to republish. Moreover, such AI-powered systems can support lifelong learning. Luckin et al. (2016) imagine cloud-based 'lifelong learning companions' for continuous personalized upgrading of skills, accessible via various devices. In this regard, AI systems could analyse how sought-after skills in job advertisements evolve and learning material could be developed accordingly for all levels, including lifelong learners.

Personalized learning does not only require communication in both directions, but also in an inclusive manner. Therefore, developers should ensure appropriate options for students' input, through speech recognition, of course, but also other modalities, such as gesture and gaze-based input, for which AI solutions have been developed and are being refined (see, for example, Worsley et al., 2018). These could be implemented as AI-driven chatbots or avatars.

FIGURE 12
Six levels of automation of personalized learning
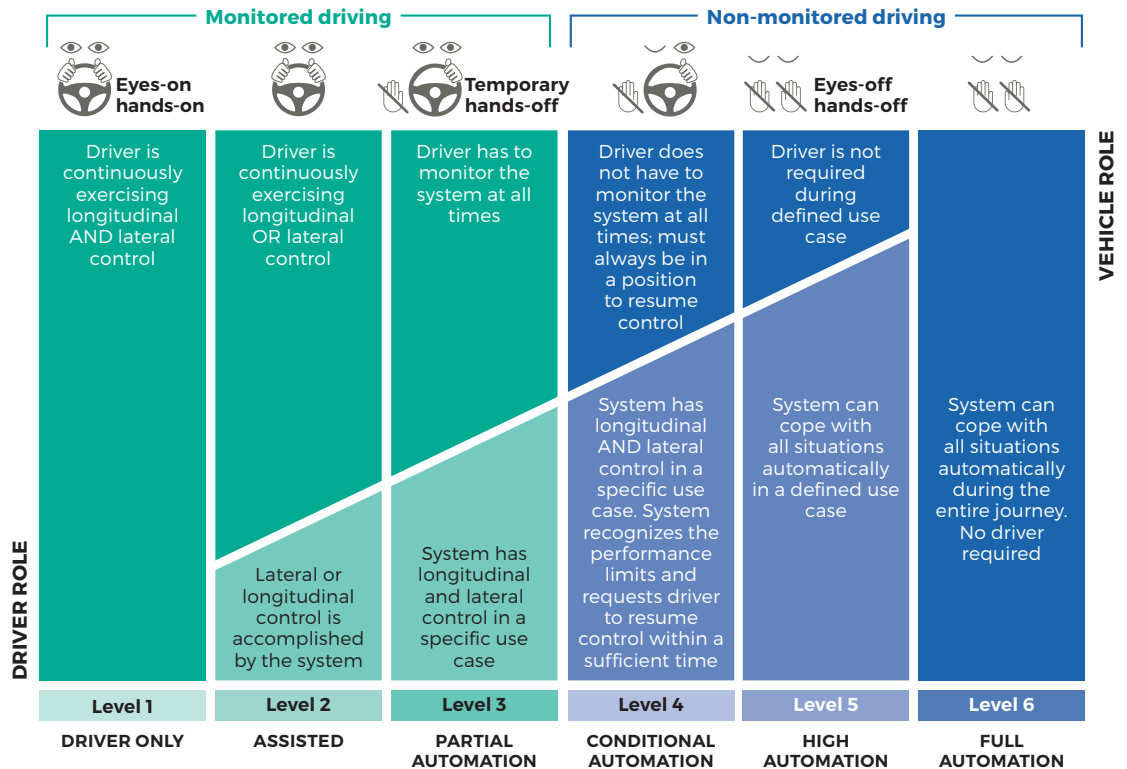
Source: Illustration – Anne Horvers and Inge Molenaar, Adaptive Learning Lab https://www.ru.nl/bsi/research/group-pages/adaptive-learning-lab-all/

	Monitored driving			Non-monitored driving		
	Eyes-on hands-on		**Temporary hands-off**		**Eyes-off hands-off**	
VEHICLE ROLE / DRIVER ROLE	Driver is continuously exercising longitudinal AND lateral control	Driver is continuously exercising longitudinal OR lateral control	Driver has to monitor the system at all times	Driver does not have to monitor the system at all times; must always be in a position to resume control	Driver is not required during defined use case	System can cope with all situations automatically during the entire journey. No driver required
		Lateral or longitudinal control is accomplished by the system	System has longitudinal and lateral control in a specific use case	System has longitudinal AND lateral control in a specific use case. System recognizes the performance limits and requests driver to resume control within a sufficient time	System can cope with all situations automatically in a defined use case	
	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**	**Level 6**
	DRIVER ONLY	ASSISTED	PARTIAL AUTOMATION	CONDITIONAL AUTOMATION	HIGH AUTOMATION	FULL AUTOMATION

Molenaar (2021) discusses six levels of automation of personalized learning, as illustrated in Figure 12. At one extreme, the teacher controls everything, while at the other extreme, the lesson is fully automated. Molenaar considers full automation undesirable and prefers hybrid human-AI learning technologies (as shown between the two extremes), where human and artificial intelligence reinforce each other.

The benefits of intelligent tutoring systems, as discussed above, may also help tackle the challenge of teacher shortages, which was exacerbated by the COVID-19 pandemic (UNESCO, 2021c).

CASE STUDY 7

AI-driven learning tool: Chimple
Learning (formal) and Evaluation

Chimple is a gamified, intelligent tutoring system (personalized and adaptive learning platform) that guides learners without any previous learning experience to a level where they can read, write and perform basic arithmetic.[i] A learner creates an identity by choosing one of forty avatars and entering their own name and age. Thereafter, learners take a diagnostic test for each subject. The test determines their stage of learning and automatically begins recommending lessons. Students can either follow the AI-guided lessons or choose their own path by clicking on any subject. Chimple tracks the learner's performance, accuracy and progress, and this data is available for the learner's parents to view. Teachers can also follow children's performance and progress through Chimple Class, an application developed for teachers.

Chimple introduces eleven possible 'AI friends' to the learner, to be their guide/teacher through the course of learning. The chosen friend gives audio instructions about the games and how to play them. When learners pass a lesson, they get rewards in the form of 'food' for their friends. Passing each stage helps them unlock accessories for their friends, read new stories or create their own sticker books. These rewards motivate children to clear challenges and learn lessons faster, especially when they are working in groups.

Every lesson has three to six tests at the end. This is a bit more challenging than working on the activities since the tests do not have a self-corrective method, which means that students do not get a second chance if they get the wrong answer. Based on their scores in such tests, students are rated and receive one, two or three stars. These stars indicate the students' learning outcome from each particular lesson. Learners also face checkpoint challenges after every three to five lessons.

Chimple is being used in government-funded schools in different states like Haryana, Maharashtra and Assam.[ii] In 2018, Chimple was selected as a finalist for the Global Learning XPRIZE.[iii]

_____

[i] https://www.chimple.org/

[ii] http://www.millenniumpost.in/opinion/nexus-of-good-playful-learning-443579

[iii] https://www.xprize.org/prizes/global-learning/teams/chimple

Permanent access

In scenarios that allow for permanent access, students are no longer constrained by daily timetables, but can benefit from 24/7 access (as long as the internet is available) to AI-powered educational tools, thus studying in a time- and location-independent manner.

Permanent access is a benefit of AI in Education that comes as a by-product of personalized intelligent tutoring systems once they are implemented along with the required infrastructure. In scenarios that allow for permanent access, students are no longer constrained by daily timetables, but can benefit from 24/7 access (as long as the internet is available) to AI-powered educational tools, thus studying in a time- and location-independent manner.

This may serve the lifestyle of today's young generation, which prefers doing all kinds of activities on smartphones or tablets whenever it has spare time. Moreover, this feature allows for an even more remarkable opportunity, which is to attend courses and avail of learning materials from all over the world, from the best tutors (Kuprenko, 2020). An AI-powered personalized learning system should have no obligation to only choose national content, but should focus on selecting the most suitable learning materials from all that is available globally. At the same time, it should ensure that any international content selected by it respects national cultures, practices and traditions, and follows the set curriculum.

Permanent access also constitutes a major opportunity for India and its rural areas, while taking into account potential constraints such as internet access and proprietary content on the one hand and language barriers and accessibility for marginalized groups on the other. Such technology can increase accessibility for women, linguistic minorities and differently abled students, as will be described below.

Glocalization

This opportunity is also referred to as 'glocalization' or the intelligent delivery of 'glocalized' remote education. Personalized learning enables students to exercise greater autonomy in their learning paths while also

Above: AI-powered adaptive personalized online learning platforms can help students access educational material in their mother tongues and from different locations. Hebbagodi Government School, Bengaluru, Karnataka, India.

promoting inclusive teaching, as digital learning content is provided over the web and can help students learn remotely at their own pace. Glocalization must not be confused with (neo) colonialism in the sense that Western learning materials are imposed on other nations (see Chapter 5: Challenges for India). In contrast, there will be free choice of learning materials within the framework of nationally determined macro-concepts, and, ideally, culturally diverse learning materials will flow in all directions around the globe.

The rapid spread of COVID-19 and the resulting closure of schools and educational institutions across major economies of the world has created a need for remote educational infrastructure. AI can usher in a new era of ubiquitous remote education, especially in developing and underdeveloped economies where there are teacher shortages. Such systems can also reach more students than traditional educational infrastructure, while automating all those functions of teaching that do not require a human instructor.

Courses taught by one teacher can be recorded and broadcast live to students over a large geographical region, thereby enabling mass education during times of crisis like the COVID-19 pandemic. From the students' perspective, AI solutions installed in learning devices (laptops, desktops, tablets, mobile phones, etc.) can translate the teacher's words in real time for students who are not fluent in the primary medium of instruction, while also providing auto-generated subtitles for easier comprehension (see the section on 'Representation of linguistic

diversity' below). From digital textbooks to study materials provided from a central repository, machine learning algorithms along with text translation can help create content that is personalized for each student's requirements. AI-based text summarization and voice transcription solutions installed in learning devices can help transcribe complete lectures into comprehensible paragraphs in multiple languages with great accuracy. This implies that a lecture delivered centrally can be customized for students through distributed decentralized content translation and transcription systems.

Another by-product of glocalized AI approaches is that they support collaborative learning. Collaborative learning is efficient, yet group formation may not happen easily, let alone in an optimized way, especially in virtual environments (Luckin et al., 2016). Luckin et al. suggest that AI systems can assist in various ways: for example, by forming the most suitable groups based on the skills of the members, by appointing intelligent virtual agents, or by offering intelligent moderation. Thus, Indian students from different parts of the country, who might never meet each other otherwise, could become collaborators; even international groups could be formed by using AI-powered translation technology, if required.

AI-powered remotely delivered learning material could be greatly enhanced by AI-supported technologies such as augmented reality, virtual reality and the metaverse. This could, however, include authentic immersive experiences of environments that are dangerous or geographically or historically inaccessible (see, for example, Luckin et al., 2016).

BOX 5

What can India offer to the world in AI?

When this report discusses AI literacy in India (see Chapter 3), it must be noted that developing these skills has an impact not only on India but also on other parts of the world to which India is exporting both human AI talent as well as AI products. Therefore, it can be seen as India's global responsibility that the human dimension of AI literacy be given utmost attention in the country's curricula, so that Indian citizens providing AI expertise to other countries always remain conscious of the larger social good of their activities by paying attention to the risks of AI (B. Rao, personal communication, April 2022).

As has been frequently reported by the media,[i] various leading Silicon Valley technology companies and others are led by Indian women and men. While this is certainly impressive, it is noteworthy to recall that not all these companies work on AI, though some do, including Alphabet/Google, Microsoft and Twitter. Furthermore, this report could not establish the extent of the AI literacy of these individuals nor whether this was a criterion in their appointment to their current positions.

Huang et al. (2020) examined the national origins of the founders of the top fifty AI start-ups in the United States and found that 53 of the 125 founders (42 per cent) were first-generation immigrants. Fourteen of the founders (11 per cent) were of Indian origin, which makes India the largest source of these founders (see Figure 13).

Unfortunately, the data in Figure 13 lacks disaggregation by sex. Moreover, all this information is limited to migration to the USA.

Besides the export of human AI talent, another metric to measure India's impact on other parts of the world in terms of AI is the export of AI products, especially AI-powered education tools. While this report could not find concrete numbers, India's global responsibility to mitigate the risks of AI should be noted, as outlined in Chapter 5: Challenges for India. AI-powered educational tools exported by India should be sensitive to the culture and the socio-economic minorities of the country of importation, for example, by training the systems on unbiased and inclusive data from the country of importation and not exporting AI systems pre-trained on data from Indian students.

_____

[i] See, for example, https://www.bbc.com/news/world-asia-india-59457015

FIGURE 13
Countries of origin of founders of the top 50 AI start-ups in the USA
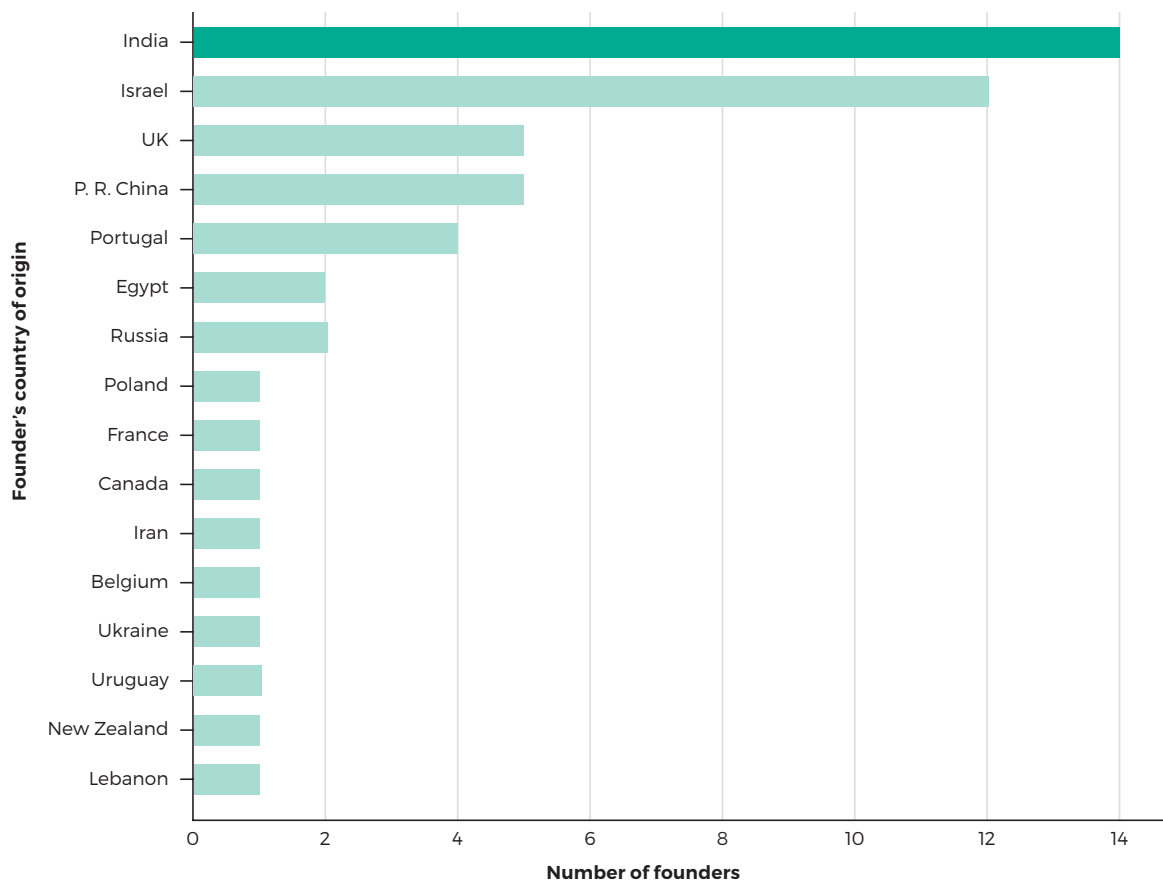
Source. CSET analysis of Forbes AI 50, LinkedIn, and other sources. A founder's country of origin is the first country where our research confirms they were born, studied or worked.

Role of parents

If students have AI-powered education tools at home, their parents have access to them too. Since parents are key stakeholders in the education of their children, this presents another opportunity, provided the parents are IT-literate or that some access to the system is ensured (through text-to-speech, for example). AI tools could support parental engagement by allowing them to view their children's performance and other data as well as resulting insights, thus supporting an active collaboration between parents and their children (UNESCO, 2020).

However, a survey of parents in the United Kingdom revealed that they are rather concerned when it comes to the following aspects of AI in Education: determinism (78 per cent), data privacy and security (73 per cent), transparency (77 per cent), accountability (77 per cent), social equity (64 per cent) and bias and discrimination (61 per cent) (Baker et al., 2019). A lesson from these survey results would be that parents in India whose children use AI in Education need to be thoroughly informed about the opportunities as well as the challenges of these systems.
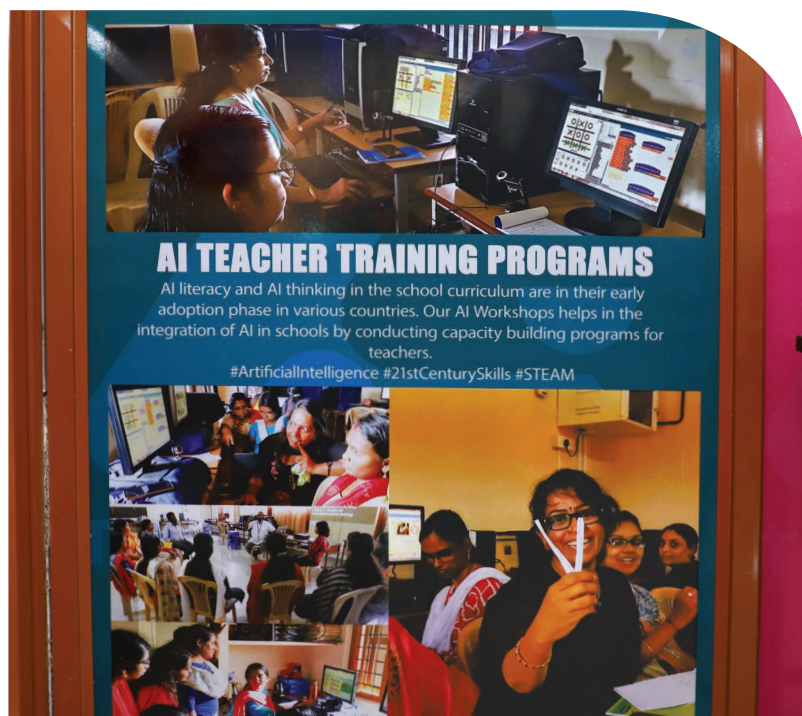
Opportunities for teachers

AI provides several opportunities for the empowerment of teachers in India, ranging from novel ways for them to continue their own education to making their routine tasks more efficient, thus increasing their availability for their students. As will be shown, the fear that AI will replace teachers is unsubstantiated, for now.

Currently, teachers spend up to 40 per cent of their working hours on administrative and routine tasks, which could potentially be automated. These comprise activities related to teaching, such as developing curricula, educational materials and assignments, and answering frequently asked questions, as well as

Below: It is crucial to train teachers in the field of Artificial Intelligence. Amrita Vishwa Vidyapeetham, Kerala, India.

activities related to evaluation, such as tracking learning outcomes, assessing competencies, grading assignments and essays, and detecting plagiarism and cheating. If these were to be taken over by AI-powered tools, teachers would be able to use the time to focus on guiding, mentoring and coaching students through one-to-one communication instead (Bryant et al., 2020; UNESCO, 2019c). This also constitutes a refocusing on critical socio-emotional, creative, empathetic and inspirational aspects of the teacher's profession, beyond administration and knowledge transfer. Lee and Chen (2021) foresee two critical roles for teachers in this scenario: in addition to stimulating students' critical thinking, teamwork, values and resilience, teachers will have the option, if required, to adjust AI-powered tools in ways that will best tackle students' needs, based on the teachers' experience and prudence.

As with any innovations and new technologies, teachers may be initially hesitant, sceptical and concerned about the upcoming changes. Therefore, it is crucial that this transformation be conducted in a transparent and open manner and that teachers (as well as students and parents) participate in the design of AI tools. Only then can these tools reflect the reality of a particular environment (see, for example, Luckin et al., 2016). In many cases, however, this requires improving teachers' competence in AI and data literacy (see Chapter 3: AI literacy in India), which also includes the ethical aspects of AI (see Chapter 5: Challenges for India). Besides ensuring their own AI literacy, teachers ought to take advantage, in the same way as students would, of personalized and glocalized AI-powered tools to continuously upgrade and adjust their other skills and knowledge. Eventually, students will benefit from their teachers' continuous, lifelong learning.

Above: A teacher and his students have an animated discussion in an AI Skills Lab. Dr Rajendra Prasad Kendriya Vidyalaya, New Delhi, India.

Artificial Intelligence in school management

AI tools can assist school management in various ways, especially in the following categories: drop-out risk detection, as already described above, management of school administration and premises, surveillance of school premises, biometric attendance systems, and remote authentication and proctoring of students, of which the last is also discussed in the section on 'Fakes and forgery' in Chapter 5.

Predictive analytics based on real-time data can support the management of school administration and premises in moving from reactive to proactive actions when it comes to resource planning, provision of substitutes for absent teachers, building maintenance and repair, etc. (UNESCO, 2020). AI tools in combination with smart building technology could, for example, help lower energy costs in school buildings by ensuring that lights, cooling and heating are used based on actual needs and on forecasts generated from historical data and patterns (UNESCO, 2020).

AI-powered surveillance systems could detect dangerous or inappropriate activities in classrooms and schoolyards. This has the twin benefits of creating safe and non-violent learning environments and relieving teachers of such monitoring tasks (see Chapter 5 for risks of surveillance systems: 'Data privacy and ownership'). Such smart technology could also support accessibility to school buildings for visually or mobility-impaired students.

As for biometric attendance systems, there are various AI-based methods to verify the identity of students entering school premises, and thus track who is on campus and when. Some of these methods are illustrated by case studies from Assam, Tamil Nadu and Uttar Pradesh.

Authenticating students is important for exams, especially if conducted remotely, as was often the case during the COVID-19 pandemic. This can be achieved through AI-powered tools such as biometrics, including behavioural biometrics (facial or voice recognition, keyboard or mouse dynamics) as well as text forensics (Burns, 2021; Yampolskiy and Govindaraju, 2008).

CASE STUDY 8

AI-driven attendance systems in Indian schools
School management

The Indian schooling system is one of the largest in the world: it catered to some 265 million students in 2019/20.[i] The large number of students in classes makes tracking students' attendance a tedious task, especially given the limited teaching time and resources. Apart from being time-consuming, manual attendance registers are susceptible to both proxies and human error (Reddy et al., 2019).

To resolve this problem, schools in the states of Uttar Pradesh, Assam and Tamil Nadu have taken initiatives to use AI-driven attendance systems. Attendance systems work primarily with facial recognition. The application scans and registers the attendance of students during school activities such as being present at morning prayers, entering school or attending classes. The system helps register students' attendance seamlessly and transparently. However, it is important to be mindful that there are concerns about using a facial recognition system to keep students' records (Nottingham et al., 2022). The lack of proper guidelines for the collection, handling, storing and sharing of students' data may breach users' privacy.

In 2020, the Tamil Nadu e-Governance Agency completed the pilot test of an AI-based facial recognition system and installed it across 3,000 schools in the state. Reportedly, the system saves around 45 minutes per day, which were earlier wasted in attendance-taking, and its implementation resulted in an 85 per cent drop in tardiness and an improvement in the overall productivity of the class.[ii]

The attendance-marking system is prepared through five phases. First is the data collection phase, in which short videos of students are taken from different angles, with an emphasis on facial features. In the second phase, which focuses on pre-processing, each video is cropped and cleaned, and a thumbnail is generated using fifty pictures. In the third phase, a neural network-based facial recognition engine is trained based on students' data. The fourth phase is evaluation, in which the trained machine learning model is tested with a collection of photos it has never seen before. For this phase, the machine learning model undergoes continuous training until its facial recognition accuracy reaches 99.6 per cent. In the final phase of deployment, the system recognizes actual students and records their attendance.[iii]

In 2021, the RailTel Corporation of India Ltd. implemented an AI-based identification system to record attendance and manage a Student Database Management Information System in Assam's government schools. Following its deployment, 48,000 schools across Assam's 33 districts, including elementary, secondary and upper secondary institutions, are benefiting from the system.[iv]

Similarly, the Kasturba Gandhi Balika Vidyalayas (KGBVs) in Prayagraj, Uttar Pradesh, plan to use an AI-powered application to mark attendance. It will be deployed in twenty KGBVs in the district through a mobile application with pictures and student data stored in its database, and priced at INR 12,000 for each AI system.[v] The app aims to reduce the 15 minutes spent on taking attendance to just seconds. The app is being developed with a facial recognition and a text delivery system. The facial recognition system will mark attendance on a digital sheet, with a list of absentees automatically generated once the app is closed. Thereafter, a text message will be sent to the block education officer.[vi] This app aims to benefit over 2,000 girls and teachers in the KGBVs.[vii] During the implementation of such systems, it is important to consider the ethical use of data and the privacy concerns of users.

[i] https://www.livemint.com/education/news/india-added-4-2-million-students-hired-250-000-teachers-in-201920-11625139066629.html

[ii] https://indiaai.gov.in/case-study/an-ai-based-facial-recognition-system-to-automate-attendance-in-public-schools

[iii] https://analyticsdrift.com/how-two-indian-states-kick-started-ai-based-attendance-systems-in-their-schools/

[iv] Ibid.

[v] https://analyticsdrift.com/ai-app-to-mark-attendance-of-students-at-prayagraj-kgbvs/

[vi] https://timesofindia.indiatimes.com/city/allahabad/ai-driven-app-to-mark-attendance-at-kgbvs/articleshow/90767850.cms

[vii] Ibid.

Equality, equity, inclusion and improved learning outcomes

This section concludes that the opportunities outlined in the previous sections of this chapter could lead to equality, equity, inclusion and improved learning outcomes in India, thus bridging or forestalling a digital divide while reaching the desired goals of the education sector in India and working towards the achievement of SDG 4. Several of the opportunities outlined above, including adaptive learning tools for customized learning, intelligent and interactive tutoring systems and predictive tools to inform pre-emptive action for students predicted to drop out of school, have also been envisaged by NITI Aayog (2018) as to be adapted to the Indian context.

BOX 6

SDG 4 and AI-powered education tools in India

The first key takeaway of the UNESCO International Conference on Artificial Intelligence and Education was that AI is envisioned as a new tool to accelerate progress towards the achievement of SDG 4 (UNESCO, 2019). In this regard, it must be noted that the entire 2030 Agenda for Sustainable Development, which includes all the SDGs, their targets and indicators, does not mention AI at all. The relevance of AI may not have been realized at the time of drafting. However, AI systems may have a significant impact on many SDG targets, in both positive and negative ways (Ziesche, 2017; Vinuesa et al., 2020). Vinuesa et al. provide an overview of whether AI could act as an enabler and/or (if wrongly handled) as an inhibitor for every SDG target. For SDG 4, they conclude that AI systems have the potential to enable all ten targets, although AI may also inhibit seven of the targets.

Table 14 provides an overview of the extent to which AI-powered education tools could support the achievement of the ten targets of SDG 4 in India. In the fourth column of this table, the seven targets that, according to Vinuesa et al. (2020), may be inhibited by AI are coloured grey. For specific AI-related risks that may inhibit the achievement of the SDG 4 targets, see UNESCO (2021e) for a global overview and Chapter 5 of this report for challenges specific to India. Examples mentioned by Vinuesa et al. (2020) are 'the conflict between AI instructors and local culture and context, which might eventually lead to poorer results' and the lack of 'policies in order to ensure fair access to technology across genders, which has great implications in education'. It is beyond the scope of this report to outline how AI-powered education tools may also act as enablers (e.g. by reducing poverty due to better and more inclusive education) as well as inhibitors (e.g. by increasing unemployment due to automation and by increasing energy consumption due to digitization) of other SDGs in India.

Above: It is imperative to ensure that new technologies, including AI, are made inclusive for all. Amar Jyoti School, Delhi, India.

Opposite page: Over time, biometric devices are becoming the norm to check attendance in many schools and institutions. Amrita Vishwa Vidyapeetham, Kerala, India.

TABLE 14
AI-powered education tools in India that support SDG 4

SDG 4 target	Description	AI as enabler (Vinuesa et al., 2020)	AI as inhibitor (Vinuesa et al., 2020)	Enabling AI-powered tools[90]	Examples of enabling AI-powered tools in India
4.1	By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes			Personalized and permanently accessible ITS	Jungroo[91] is an AI-powered assessment, evaluation, practise and learning platform
4.2	By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education			Personalized and permanently accessible ITS	Chimple[92] provides AI-customized reading, writing and mathematics lessons for small children
4.3	By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university			Personalized and permanently accessible ITS	e-Khool[93] is an AI-powered online learning management system
4.4	By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship			Personalized and permanently accessible ITS	Skill-X[94] is an AI-driven end-to-end employability solution
4.5	By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations			Personalized and permanently accessible ITS, AI tools for differently abled students, AI tools for linguistic minorities	I-Stem[95] empowers students and professionals with disabilities
4.6	By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy			Personalized and permanently accessible ITS	Countingwell[96] creates a personalized AI-based 'Maths Workout Plan'
4.7	By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development			Personalized and permanently accessible ITS	
4.a	Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all			Smart building technology and AI-powered surveillance systems	CamfyVision's FacEAI-PRO[97] is a facial analytics solution meant to improve children's safety in schools and pre-schools using AI
4.b	By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries				

Source: Compiled by authors

[90] See Chapter 4: Opportunities for India.
[91] https://jungroo.com/
[92] https://www.chimple.org/ See also the case study on Chimple in this chapter.
[93] https://ekhool.com/
[94] https://inurture.co.in/krackin-skillx/
[95] https://www.istemai.com/
[96] https://www.countingwell.com/index.html
[97] https://indiaai.gov.in/case-study/ai-to-improve-children-s-safety-in-schools-and-pre-schools-using-ai
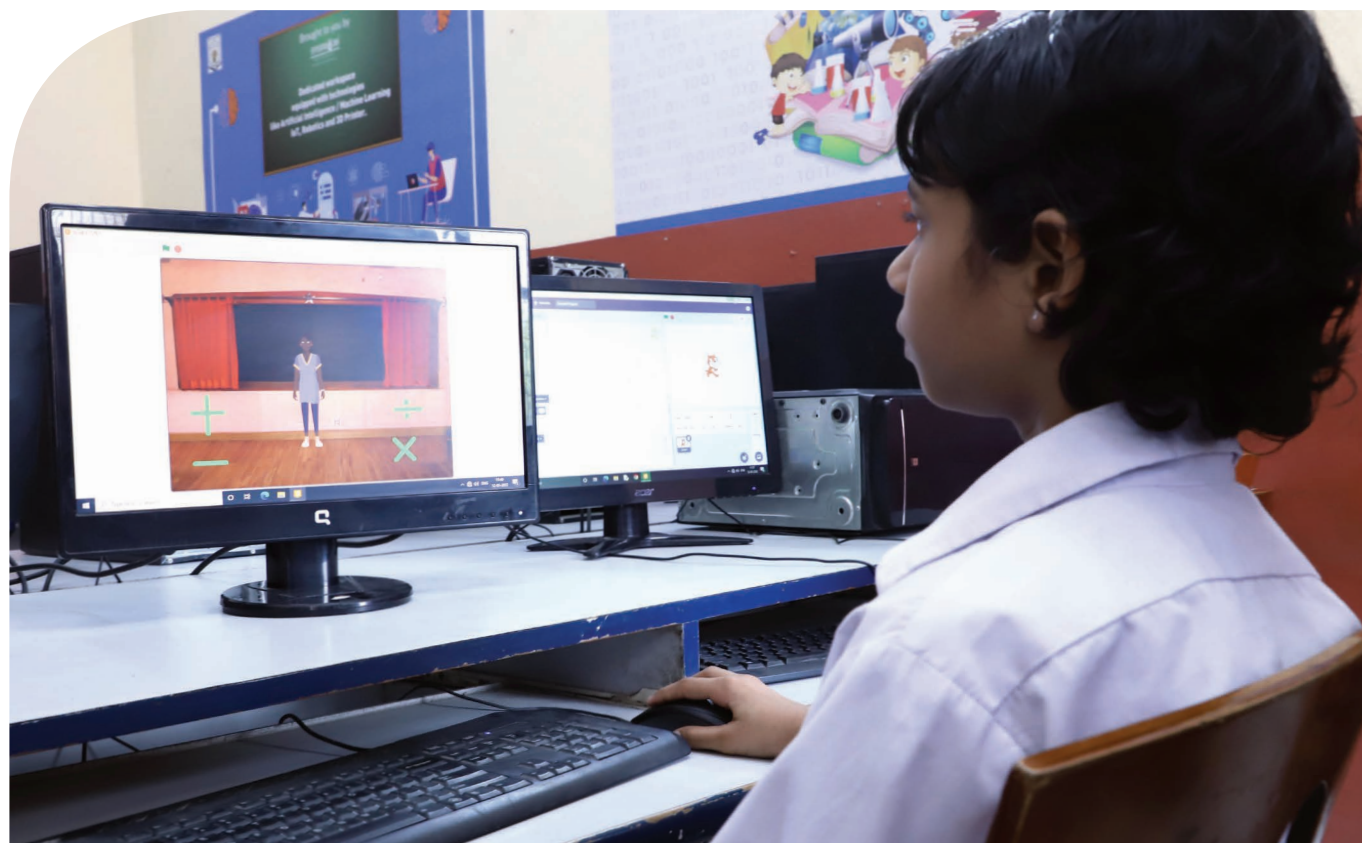
SDG 4 target	Description	AI as enabler (Vinuesa et al., 2020)	AI as inhibitor (Vinuesa et al., 2020)	Enabling AI-powered tools[90]	Examples of enabling AI-powered tools in India
4.c	By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States			Personalized and permanently accessible ITS for teachers and lifelong learners	

As discussed, AI-powered education tools can provide personalized intelligent tutoring systems for everyone by employing an enormous amount of data (individual skills, knowledge, progress, etc.) much of which have not been systematically collected before, and by harnessing a vast amount of national and international learning material, to be accessible anywhere and anytime. If this is implemented and challenges such as the lack of required policies and infrastructure are overcome (see Chapter 5: Challenges for India), it could bring unprecedented equality and equity to education in India. Improved learning outcomes are likely to follow due to the abolishment of the restrictive one-size-fits-all approach and the AI-powered discovery of patterns and trends, within assessments, that support the continuous fine-tuning of personalized intelligent tutoring systems.

For these innovations to be inclusive, too, further provisions must be made, some of which have been introduced above. With regard to inclusion, there is a distinction between groups whose inclusion can be supported by AI tools and technology, and groups whose inclusion requires support from government policies and other arrangements. To the latter group belong girls and marginalized communities in India who are deprived of any education at all. These children cannot be reached by AI tools and technology since they do not attend school. Therefore, arrangements have to be made to enrol them. The former group includes differently abled students and those belonging to linguistic minorities. This group was also mentioned by the Beijing Consensus on Artificial Intelligence and Education as follows: 'Ensure that AI tools in teaching and learning enable the effective inclusion of students with learning impairments or disabilities and those studying in a language other than their mother tongue' (UNESCO, 2019a, p. 39).

Below: Game-based learning can help hone mathematical skills. Modern Public School, Delhi, India.

Inclusion of differently abled students

Above: A visually impaired student using a keyboard especially designed for persons with disabilities. Amar Jyoti School, Delhi, India.

The 'Rights of Persons with Disabilities' Bill from 2016 defines twenty-one different types of disabilities in India.[98] Mobility-impaired students and those in hospitals or based in facilities for differently abled people could benefit from location-independent learning, as introduced above. While it is desirable, ultimately, to have AI-powered education tools for all types of disabilities, Indian companies have developed AI tools for only some of them as of now, and not always with a focus on education. This is illustrated in Table 15.

> Mobility-impaired students or those based in facilities for differently abled people could benefit from location-independent learning and, ultimately, from AI-powered education tools.

TABLE 15
Indian AI-based tools for differently abled people, including students

Name of tool	Type of disability
EYE-D[99]	Visually impaired
Let's Talk Sign[100]	Hearing-impaired, speech-impaired
I-Stem[101]	Various disabilities
Cogniable[102]	Autism
AttentionKart[103]	Special needs
Stamurai[104]	Speech-impaired
Metanoa[105]	Various disabilities

Source: Compiled by authors

[98] https://pib.gov.in/newsite/printrelease.aspx?relid=155592

[99] https://eye-d.in/

[100] https://www.letstalksign.org/

[101] https://www.inclusivestem.org/

[102] https://cogniable.tech/in/

[103] https://www.attentionkart.com/

[104] https://stamurai.com/

[105] https://metanoa.ai/

Eye tracking-based assistive technology for the Indian population
Learning (formal)

People with severe speech and motor impairment (SSMI), often caused by cerebral palsy or Amyotrophic Lateral Sclerosis (ALS), depend on eye-tracking based assistive technology for daily communication, education, work and rehabilitation. The effect of ALS or cerebral palsy on visual search and eye movement patterns are often not rigorously investigated and existing commercial assistive technology turns out to be difficult to use. The problem is even more compounded for the Indian population as many people cannot afford existing commercial products and lack of investigation on human factors and privacy aspects push people away from technology. A team from the Indian Institute of Science (IISc) is working with the Spastic Society of India to provide end-to-end solutions for students with cerebral palsy and ALS. The following steps summarize the development process:

USER INTERFACE DESIGN GUIDELINE

Most user interfaces are populated with screen elements from top to bottom and left to right. However, an eye-tracking study of more than twenty users with SSMI found that they struggle to fix attention on the top-left corner of a screen and their gaze moves in a radial fashion from the centre of a screen instead of from top to bottom and left to right. The IISc team designed and validated a set of education and communication software that are under regular use by end users. Users preferred screen elements of a specific size with sufficient inter-element spacing and placed at the middle of the screen (Jeevithashree et al., 2019 and 2020).

DEEP LEARNING BASED EYE TRACKER

A webcam-based eye tracker is more affordable for everyday use than high-end commercial eye trackers. The IISc team investigated existing webcam-based eye-tracking software and developed a bespoke dataset involving the Indian population, undertook cross-dataset validation and proposed a new deep learning based eye-tracking software that is trained with the Indian dataset and generated state-of-the-art accuracy with other published datasets (Murthy and Biswas, 2021).

INCLUSIVE HUMAN-ROBOT INTERFACE

Users with severe motor impairment could not manipulate any physical objects, thus limiting their rehabilitation prospects. The IISc team developed safe eye-gaze-controlled human-machine interfaces. By placing screen elements at appropriate positions and using safe and intelligent navigation algorithms, users with cerebral palsy could undertake pick-and-place tasks with robotic manipulators (Sharma et al., 2022). The India-EU ICT Collaboration and ITU APT Foundations are organizing hackathons using technologies similar to those developed by the IISc.
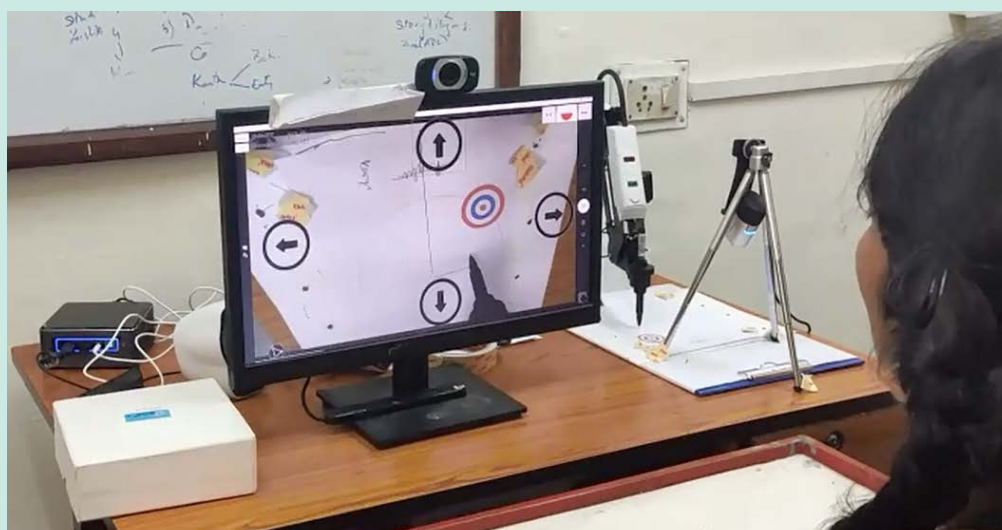
Right: Eye tracking-based assistive technology developed for the Indian population. Vidya Sagar, Chennai, Tamil Nadu, India.

Inclusion of linguistic diversity

Although there are over 19,500 languages in India, including 23 official ones, the share of English-language internet content consumed in India surpasses content in all the other languages by far. Yet, English is spoken by less than 10 per cent of the Indian population.[106]

Therefore, the inclusion of linguistic minorities in the education system is crucial. The quality of AI-based translation systems has improved significantly in recent years and these tools can, to some extent, help students learn content in another language. For example, Google translate[107] provides translation services for twenty-one Indian languages.[108] In addition, India-based companies have developed specific AI tools for linguistic minorities, as illustrated in Table 16.

Above: AI-powered adaptive personalized learning platforms that are available to students in their mother tongues can help improve learning outcomes. Hebbagodi Government School, Bengaluru, Karnataka, India.

Opposite page: Augmented reality teaching aids help bring stories alive for these children. Modern Public School, Delhi, India.

106 https://www.livemint.com/news/india/in-india-who-speaks-in-english-and-where-1557814101428.html

107 https://translate.google.co.in/

108 Assamese, Bhojpuri, Dogri, Konkani, Maithili, Meiteilon, Mizo, Sanskrit, Bengali, Gujarati, Hindi, Kannada, Malayalam, Marathi, Nepali, Odia, Punjabi, Sindhi, Tamil, Telugu and Urdu.

109 https://www.udaanproject.org/

110 https://www.microsoft.com/en-in/bhashaindia/

111 https://translation.aicte-india.org/

112 https://devnagri.com/

113 https://readalong.google/ See also the case study on Read Along in this chapter.

114 https://ai4bharat.org/

TABLE 16
Indian AI-based tools for linguistic minorities

Name of tool	Description	Indian languages covered
Project UDAAN[109]	Translation of textbooks and other study material for engineering and other streams from English to Hindi and other Indian languages	Aims to reach fifteen Indian languages
Bhasha (Microsoft Indic Language Input Tool – ILIT)[110]	Project Bhasha is a program that aims to localize (i.e. provide local interfaces to) Microsoft's Windows and Office products	Assamese, Bengali, Gujarati, Hindi, Kannada, Konkani, Malayalam, Marathi, Nepali, Odia, Punjabi, Tamil, Telugu
AICTE Translation Automation Artificial Intelligence Tool[111]	Online translation tool for English-language content	Translates online courses in English into eleven different languages: Hindi, Bengali, Marathi, Telugu, Tamil, Gujarati, Kannada, Malayalam, Punjabi, Assamese and Odia
Devnagri[112]	AI-powered human translation platform	Twenty-two Indian languages and ten international languages
Read Along[113]	App to develop reading skills with the help of an in-app assistant (Diya), which uses Google's text-to-speech and speech recognition technology	Hindi, Marathi, Tamil, Telugu, Bengali, Gujarati and Urdu
AI4Bharat[114]	Non-profit organization with many ongoing projects focused on Indian languages and AI	Translation: Twelve Indian languages Transliteration: Over twenty Indian languages Speech recognition: Nine Indian languages Language understanding: Ten Indian languages Language generation: Ten Indian languages Sign language: Ten sign languages from around the world

Source: Compiled by authors

While this chapter has illustrated various efforts towards inclusion, the potential of AI could be harnessed even further in this regard, given the various dimensions of diversity in India. Examples range from AI-based tools for illiterate lifelong learners to permanent access to intelligent tutoring systems for members of India's nomadic population.

CASE STUDY 10

AI-driven learning tool: Read Along by Google
Learning (formal) and Evaluation

n 2021, the Indian Ministry of Education launched a National Initiative for Proficiency in Reading with Understanding and Numeracy (NIPUN Bharat), which aims to ensure that every child in India attains their foundational literacy and numeracy outcomes by 2026–27. In order to contribute to this national mission, Google developed an Android app using its speech recognition technology. Called 'Read Along', the app aims to improve reading and comprehension skills of children over 5 years old by giving verbal and visual feedback as they read stories out loud. Read Along works on entry-level smartphones and tablets with 1 GB RAM and is available in English and seven other Indian languages (Hindi, Marathi, Tamil, Telugu, Bengali, Gujarati and Urdu). It also works offline and has over 1,000 stories and word games for different levels.

Read Along has an in-built reading assistant called Diya that uses Google's text-to-speech and speech recognition technology to check if a student is finding it difficult to read a passage. Diya provides real-time, positive and reinforcing feedback along the way, based on the learner's reading performance. Diya also helps students when they face any problem in pronunciation or reading. Read Along provides a personalized learning experience by recommending stories and games of the appropriate difficulty level based on the learners' reading performance. In addition, it awards stars and badges to the learners based on their performance, to motivate them to do better.

Google conducted a pilot study in 200 villages in Unnao district, Uttar Pradesh, to measure the effectiveness of Read Along. A total of 1,520 children participated in the study. The experimental group (920 children) was given the Read Along app, while the control group (600 children) did not get the app. The experimental group was given a demonstration of the app's various functions. The study lasted three months, and its results showed that 64 per cent of the children in the experimental group improved their reading scores as compared to only 40 per cent of children in the control group. Moreover, 92 per cent of the parents of participants in the experimental group claimed they were happy with the improvement in their children's scores, with 95 per cent of the parents agreeing to let their children continue to use Read Along.[i] Another study reported that 40 per cent of learners improved their reading fluency levels after using the app (Sattva, 2020).

Under a flagship programme called Mission Prerna, the Uttar Pradesh Government signed an agreement with Google to implement the Read Along app in 113,000 schools to improve the Hindi and English pronunciation of over 10 million children.[ii] A total of 550,000 teachers are being trained online by academic resource persons to use Read Along effectively.[iii] In addition, parents are being trained by the teachers to help their children use Read Along at home. Similarly, the Tamil Nadu Government signed a Memorandum of Understanding (MoU) with Google under a scheme called Illam Thedi Kalvie to improve students' language learning outcomes. The Read Along app will add licenced content from the state to improve the English reading and speaking of children from Grade 4 to Grade 9.[iv]

---

[i] https://services.google.com/fh/files/misc/read_along_pilot_findings.pdf

[ii] https://timesofindia.indiatimes.com/education/news/google-bolo-app-to-teach-up-kids-how-to-pronounce/articleshow/77523453.cms

[iii] Ibid.

[iv] https://www.newindianexpress.com/states/tamil-nadu/2022/may/06/tn-kids-can-now-read-along-with-google-2450267.html

BOX 7

Sketch of a best-case scenario

- Every student in India, including lifelong learners and members of marginalized groups, has location- and time-independent access to free high-speed internet as well a free intelligent tutoring system through a high-quality device, which the student received for free.

- The intelligent tutoring system supports differently abled students, linguistic minorities and all other marginalized groups according to their needs.

- The intelligent tutoring system tracks the learning outcomes and assesses the competencies of each student individually in real time, based on large amounts of data about all students from a variety of sources. The intelligent tutoring system is trained on data of Indian students only.

- The data is owned by the student and the only other purpose it can be used for, anonymized, is to further strengthen countrywide intelligent tutoring systems.

- Based on its analysis, the intelligent tutoring system discovers patterns and trends indicating individual strengths, weaknesses, levels of knowledge and speed of learning, and develops a personalized curriculum accordingly, which also covers artistic subjects and supports critical and creative thinking.

- The learning material of the personalized curriculum is accessible online anytime and includes selected high-quality content, potentially also from other countries, while always respecting the autonomy of the student as well as Indian culture and aligning itself with the macro-concepts identified by schools.

- Despite having an intelligent tutoring system, the main focal point for the student remains the teacher who is AI literate in both the technical and ethical aspects of AI, who has been empowered by the intelligent tutoring system and by AI-powered tools for administration and evaluation, and who can focus much more on the socio-emotional, creative, empathetic and inspirational aspects of the profession.

- Overall, students in India have improved learning outcomes because of AI in Education systems.
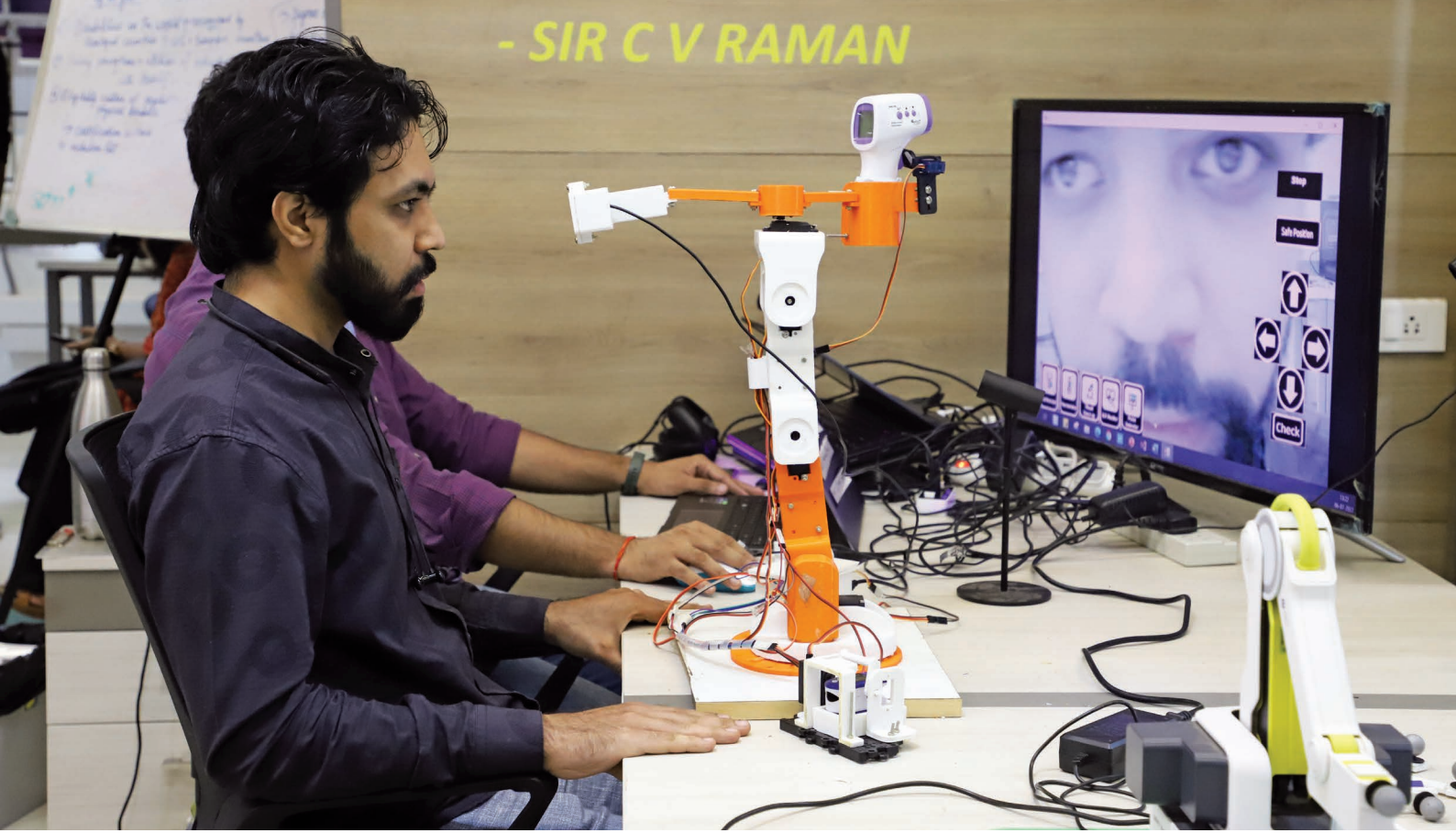
Opposite page: A collaborative robot (CoBot) for healthcare measures vital signs while maintaining social distance. Indian Institute of Science, Bengaluru, Karnataka, India.

Below: Intelligent tutoring systems support differently abled students, linguistic minorities and other marginalized groups according to their needs. Amar Jyoti School, Delhi, India.

Summary

AI-powered education tools offer opportunities across various aspects of education, which are categorized here as formal and informal learning, teaching, evaluation, school management as well as mapping and matching of skills.

The focus of this report is on the category of learning with special attention to comprehensive personalized intelligent tutoring systems and it outlines how these could bring equality, equity, inclusion and improved learning outcomes to the Indian education system.

A long-standing flaw of today's education system is its one-size-fits-all approach. Intelligent tutoring systems address this issue through tracking the learning outcomes and assessing the competencies of students individually in real time. Based on this, intelligent tutoring systems discover patterns and trends indicating individual strengths and weaknesses and develop predictive analytics as well as customized curricula, linked to learning material, that are accessible online anytime.

Intelligent tutoring systems also support differently abled students, linguistic minorities and other marginalized groups according to their needs.

Teachers are empowered by intelligent tutoring systems as well as by additional AI-powered tools for administration and evaluation, which frees them from routine tasks and allows them to refocus on the socio-emotional, creative, empathetic and inspirational aspects of teaching.

Other AI-powered tools support school management as well as mapping and matching of skills for the labour market.
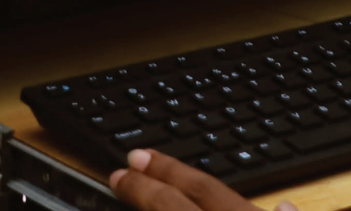
Challenges for India

Although AI holds many opportunities for India, it also has its share of challenges and risks, as is the case with many emerging technologies, and even more so given that AI is a dual-use technology. Some of these risks concern AI in general, some are specific to AI in Education, while some are specific to India's context. It is crucial to address all these risks to ensure that the opportunities for the Indian education sector, described in the previous chapter, are not delayed or forestalled.

Left: An AI-powered social robot designed to promote hand hygiene by children. Amrita Vishwa Vidyapeetham, Kerala, India.

Challenges for India

Governance and accountability of Artificial Intelligence

Below: Multi-lingual automatic speech recognition for Indian languages will help students access educational material in their mother tongues. International Institute of Information Technology, Bengaluru, Karnataka, India.

Potential AI risks are not limited to the field of education but range from bias and discrimination, via an AI 'arms race' (see, for example, Cave and ÓhÉigeartaigh, 2018), to a malicious superintelligence (Bostrom, 2014). All these significant risks need to be addressed, and they all relate to the challenge of governing AI. Governing Artificial Intelligence is humanity's attempt to govern something that is, and will become, more intelligent than humans in numerous fields, and that acts in ways that are largely opaque to humans. Research is ongoing to devise 'global norms, policies and institutions to best ensure the beneficial development and use of advanced AI' (Dafoe, 2018). However, rapid technological developments very often outpace policy debates and regulatory frameworks (see, for example, UNESCO, 2021e). Therefore, and given that the speed of technological developments may increase even further, swift action is vital.

Lack of policies for AI in Education

What applies to AI in general on a global scale is also valid in the context of AI in Education in India. Actions are especially required in areas where the private sector is strongly involved, as is the case with AI in Education in India. This is a new development, as education used to be a field traditionally managed and supervised by national governments. It is a development that creates opportunities such as pioneering products, which governments would not be able to create, as well as risks, which need to be addressed through policies. In this regard, UNESCO recommends the creation of partnerships with the private sector, since the public sector alone will not be able to make the necessary innovations at such complex technological levels (UNESCO, 2019c).

Rapid technological developments very often outpace policy debates and regulatory frameworks. Therefore, and given that the speed of technological developments may increase even further, swift action is vital.

Above: A researcher works on an intelligent IoT-based assistive device for mobility and rehabilitation. International Institute of Information Technology, Bengaluru, Karnataka, India.

Policies for AI in Education in India should address a variety of issues, which will be discussed in more detail, such as data collection and ownership, both in the private and public sectors. There should also be a focus on girls, women and disadvantaged socio-economic groups, all guided by the core principles of inclusion and equity.

Accountability is another challenge related to the fact that AI systems are often more advanced than humans, and thus, to humans, their decisions may seem to arise from an opaque black box. In other words, in many cases there is a lack of explainability about how and why an AI system produced a certain output.

> ❝
> Advanced AIs would not be able to accurately explain some of their decisions and for the decisions they could explain people would not understand some of those explanations.
> ❞
>
> *Yampolskiy, 2020, p. 1*

This dilemma does not only raise the serious problem of the accountability of AI, but is also linked to liability. For example, if an AI tool guides a student wrongly or predicts her/his learning outcomes incorrectly, the question arises of who or what is responsible and accountable. The options are: the owner or the developer of the AI tool, the teacher or the algorithm (UNESCO, 2019c).

Murphy (2019) notes two more reasons why lack of explainability is of concern:

1. It is hard to trust a system that one does not understand, especially when it produces counterintuitive predictions (for example, a drop-out risk for a student whom a human observer would not expect to drop out).

2. If humans do not understand how a system reached a certain undesired output, they will find it challenging to correct it (for example, biased systems; see 'Algorithmic fairness and biases' below).

AI-powered educational tools must be easy for teachers to comprehend, including for those teachers without a strong technical background, and must also be trustworthy. To ensure this aspect of inclusion, we need a so-called 'explainable AI', which observes the three principles of transparency, interpretability and explainability. Such technology is still a work in progress (see, for example, Angelov et al., 2021).

Porayska-Pomsta and Holmes (2023) note another requirement for AI in Education systems, in addition to transparency and explainability: that the systems should be built for human autonomy. This means that users should be able to modify or stop the systems.

Ethics of Artificial Intelligence in Education

Ethics of AI is an umbrella term for a broad and crucial field that covers several aspects of AI but is often neglected by techno-optimists and the private sector, and also in some AI curricula. As mentioned above (see 'AI in UNESCO', Chapter 2), UNESCO acknowledged the criticality of the potential ethical implications of AI early on, and achieved a milestone in 2021 by adopting the 'Recommendation on the Ethics of Artificial Intelligence'.

Holmes et al. (2021) outline how, although it is almost certain that most AI in Education practitioners have good intentions like improving the learning outcomes of students, it is critical to explicitly discuss the following non-trivial ethical issues related to AI in Education: fairness, accountability, transparency, bias, autonomy, agency and inclusion. If these challenges are not addressed early on, they could lead to unintended behaviour from AI in Education systems. Therefore, Holmes et al. (p. 1) call for a 'well-designed framework for engaging with ethics of AIED that combine[s] a multidisciplinary approach and a set of robust guidelines'. The fact that the AI in Education conferences[115] in 2018 and 2019 hosted a workshop called 'Ethics of AIED. Who Cares?' that had low attendance indicates that there is some momentum in the field, though it needs to be increased, including

Below: A student does Python programming and runs code based on Jupiter notebook. Delhi Public School Bangalore East, Bengaluru, Karnataka, India.

in terms of the engagement of stakeholders from India.

NITI Aayog (2018) acknowledges the relevance of ethics related to all aspects of AI and calls for 'responsible AI' to be incorporated in any AI strategy. Particular issues are explainability of AI (see above), but also data privacy and ownership as well as algorithmic fairness and biases, both of which are discussed below in how they relate to AI in Education. In two follow-up publications, NITI Aayog (2021a, 2021b) provides wide-ranging ethics principles for the design, development and deployment of AI in India so that the full potential of AI can be unleashed in the country within a responsible AI ecosystem. In 2020, Tamil Nadu became the first Indian state to publish a policy on AI ethics (Government of Tamil Nadu, 2020) using the DEEP-MAX Scorecard proposed by Dwivedi et al. (2019). The DEEP-MAX Scorecard is a rating system for AI systems based on seven ethical parameters: diversity, equity, ethics, privacy and data protection, misuse protection, audit and transparency, and the digital divide and data deficit.

Data privacy and ownership

The Open Data Institute defines data ethics as 'a branch of ethics that evaluates data practices with the potential to adversely impact on people and society – in data collection, sharing and use'.[116]

In the context of AI in Education, data ethics is of particular concern as the data of AI-powered education tools is routinely owned by private companies, both in India and in other countries. Often, such companies have a (side) business model based on the sale of this data for targeted advertising, without any financial benefit for the data subjects, that is, the students and teachers (see, for example, Burns, 2021).

There are two types of data: raw data and inferred data. Raw data are those that are directly gathered from the performance and behaviour of a student. An example would be that a student is always very focused during chemistry classes but lacks concentration during history classes. Inferred data are those that are derived from the raw data, usually through proprietary and non-transparent algorithms. An example would be that this student is at risk of failing in history class and may need

---

[115] As mentioned in the Introduction, the International Artificial Intelligence in Education Society organizes annual AI in Education conferences.

[116] https://theodi.org/service/consultancy/data-ethics/

additional support and/or learning content about history in a different format or by a different method.

A conflict of interest prevails between advocates of data privacy and ownership and developers of AI systems who require large amounts of training data, which is further described below. A way to tackle this issue would be to ensure that personally identifiable information and individual privacy preferences of both students and teachers are protected. This would not affect the AI tools as their algorithms could work on the data as before. Nevertheless, it is critical that everyone whose data is involved in AI in Education systems, particularly K-12 students, are not only well informed (about what data is gathered and to what extent they are used) but are also aware that there exist clear procedures for stakeholders to give or withhold their consent in this regard. This should apply to both raw and inferred data, even if the AI in Education company claims that the inferred data has been produced by an algorithm that they have developed and own. Duraiappah and Shefet (n.d.) call for an international treaty that designates a custodian for education-related data.

Akgun and Greenhow (2021) raise two issues that are closely linked to data privacy: surveillance and autonomy. AI-powered educational tools put both students and teachers under surveillance by constantly monitoring their actions and preferences (see the section on 'AI in school management' in Chapter 4 for the benefits of surveillance systems). This is not only ethically questionable and may make students and teachers uncomfortable due to infringement of privacy, but it may also limit the participation of students, who may hesitate to say certain things, given that their data will be constantly saved. Similarly, these predictive AI tools may restrict the autonomy of students and teachers and their capability to act in their own interest and in line with their own values.

CASE STUDY 11

AI-powered chatbot: Bol Behen
Learning (informal)

In 2007, Indian schools included reproductive health education for adolescents in their curricula. Yet, many of the students' questions remain unanswered because of constrained conversations and a lack of proper educators. Young people often seek answers online, but these are not always reliable. This lack of a platform to answer queries about women's physiologies and well-being was addressed by Girl Effect.

Girl Effect is an independent non-profit organization that has reached twenty countries in Asia and Africa. In South Africa, Girl Effect launched the Big Sis app that was used to answer queries by adolescent girls. The app recorded over 148,000 conversations, with over 2.8 million messages sent by girls to the bot (computer programs that automatically execute actions). Their questions were answered with 87 per cent accuracy. In 2020, following in the path of Big Sis, Girl Effect and WhatsApp (a messaging app that uses the internet to send text messages, images, audio or video) launched Bol Behen ('Speak Sister' or 'Ask Sister') on Facebook Messenger in India as an AI-powered chatbot.[i] The chatbot claims to have had 100,000 conversations with over 1.6 million messages circulated.[ii]

Bol Behen is a widely used tool for personal communication in India. The chatbot has addressed data privacy and security concerns, including with the better selection of a suitable platform for the chatbot's development, modifying privacy policies and investigating the privacy policies of third-party organizations like analytics providers (Handforth and Bertermann, 2018).

With Bol Behen, girls and women have a platform on which to ask questions about sensitive subjects like sex, relationships, reproductive health, etc. The chatbot is available on the WhatsApp Business Platform. Users simply text 'Hi' to the number +917304496601 and begin their queries. It can also be joined with a link: https://wa.me/917304496601. The chatbot is specifically designed for young girls and women in India who use low-end smartphones with limited internet bandwidth. It functions in Hinglish (an informal combination of Hindi and English) to assist women in India's Hindi-speaking belt. The conversations are very human-like and do not feel like machine answers.[iii]

Girl Effect uses this platform to enable a mode of private conversation and to make girls feel safe and unjudged while discussing intimate issues. As of August 2022, Bol Behen has been introduced for limited use as a beta version on both mobiles and the web.[iv]

---

[i] https://www.indiatimes.com/technology/news/whatsapps-new-bol-behen-chatbot-will-take-care-of-young-girls-well-being-565863.html

[ii] https://www.news18.com/news/tech/whatsapps-bol-behen-chatbot-will-help-adolescent-girls-young-women-with-health-related-concerns-4925387.html

[iii] https://indiaai.gov.in/article/whatsapp-launches-ai-powered-chatbot-bol-behen-for-women-and-girls

[iv] https://www.dnaindia.com/technology/report-what-is-whatsapp-s-bol-behen-chatbot-check-features-functions-2943484

Since the 'worldview' of AI systems relies on the data fed into them, AI systems adopt these biases, or even amplify them, thus contributing to mis- and dis-information as well as the proliferation of existing socio-economic divides.

Below: A teacher explaining different aspects of Artificial Intelligence in class. Modern Public School, Delhi, India.

Algorithmic fairness and biases

The next ethical issue is related to the algorithms that process and analyse data. These algorithms come up with predictions and instructions that need be to fair and unbiased. Unfortunately, algorithmic bias has become a serious issue in recent years across many fields where AI systems are used. Such bias involves algorithms favouring certain groups while discriminating against others. Some of the criteria observed for bias have been race, gender, sexuality and ethnicity.

It must be pointed out that an AI system is not biased per se. The reason for such behaviour from algorithms is the underlying training data, which often represent the historical and systemic biases of a society. In addition to the feeding of biased data into the algorithm by the creators of these AI systems, unintentionally or intentionally, this issue is also caused by the withholding of data for certain groups, unintentionally, intentionally, or very often due to unavailability. Since the 'worldview' of AI systems relies on the data fed into them, AI systems adopt these biases, or even amplify them, thus contributing to mis- and dis-information as well as the proliferation of existing socio-economic divides. UNESCO addresses issues of algorithmic discrimination and, for example, calls upon the private sector and the technical community to 'adopt techniques to fix gender-based and other biases in datasets' (UNESCO, 2019b, p.145).

As this is a wide-ranging subject, this report only addresses the different 'axes of potential Machine Learning (un)fairness in India', and related issues of inappropriate or lack of training data. While the issue of algorithmic bias has received necessary attention in recent years, the related research is Western-centric, or US American-centric in particular, in the sense that the dimensions of discrimination being examined are predominantly race and gender; in other words, dimensions that are relevant in that part of the world. Indeed, Sambasivan et al. (2021, p. 10) point out that context matters and that 'we must take care to not copy-paste the western-normative fairness everywhere'.

India is not only very diverse but also suffers from widespread marginalization, which is reflected in the education system. This poses the risk of AI continuing 'in a more sophisticated manner, to do what the caste system did in terms of sifting people into different categories based on socio-economic backgrounds and assigning them education and vocational possibilities that further reinforce the stratification. By reproducing a future based on the past, AI discourages aspirational advancements' (Kasinathan, 2020, p. 8). To reach algorithmic fairness in India, the country's societal composition must be analysed and biases identified based on this analysis. Sambasivan et al. (2021) present seven 'axes of potential Machine Learning (un)fairness in India',
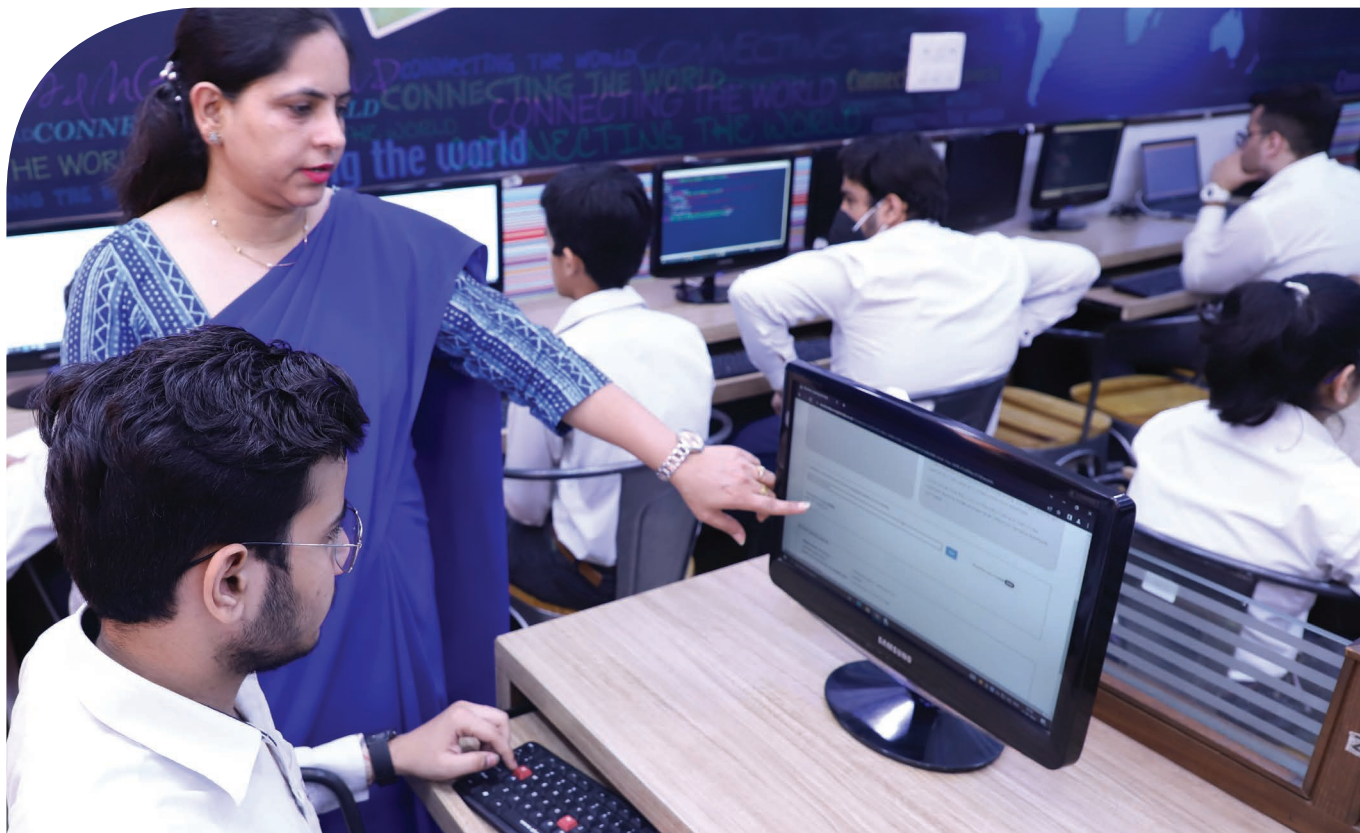
In order to fully benefit from AI in Education systems, their flaws need to be corrected first.
The solution for algorithmic biases and discrimination lies in appropriate training data for AI in Education systems.

Above: Students work on Python programming running codes on computer vision. Delhi Public School Bangalore East, Bengaluru, Karnataka, India.

which include the subgroups of gender, religion, ability, caste, class, gender identity and sexual orientation, and ethnicity. Barring one, all the subgroupings of social inequalities listed above can be found in many other countries around the world. As long as the desired scenario of algorithmic fairness has not been fully achieved, Holmes et al. (2021) stress that we must address how affected students and teachers could opt out from, or challenge how they are represented in, large datasets.

Lastly, it must be noted that evidence exists of teachers being discriminatory in various parts of the world, including India. For example, Rawal and Kingdon (2010) discovered that teachers in India tend to grade students better when the teacher and the student share the same gender, caste and religion as compared to when this is not the case. It is for instances like this that AI in Education systems were envisioned as a remedy to ensure objective grading and impartiality.

However, in order to fully benefit from AI in Education systems, their flaws need to be corrected first. The solution for algorithmic biases and discrimination is appropriate training data for AI in Education systems. The critical feature of these data would have to be that they enable the creation of a worldview of the AI systems where neither bias nor discrimination exists. This would require a shift from the current approach of training data reflecting the real world, which is infested with historical and systemic biases and discrimination, to an approach of training data depicting an ideal world, where such phenomena are absent. The latter approach necessitates another complex layer of data cleaning and editing before entering them to AI systems. On the other hand, access to training data constitutes a major challenge for AI in Education in itself, which is outlined below.

Access to training data

Such data
are often
only available
from existing
AI-powered
education tools,
which is not only
comparable to the
chicken-or-egg
causality dilemma
but also linked
to several further
challenges.

——————

Below: An interactive tool allows access to data from the Karnataka Government via multiple sources in a data lake application. International Institute of Information Technology, Bengaluru, Karnataka, India.

As discussed above (see 'Big data', Chapter 4), the output of machine learning systems depends greatly on the quantity and quality of their training data. The more and better the data, the better the system's output can be expected to be. Following this general rule is often a challenge for AI in Education systems due to the difficulty of acquiring suitable training data (see, for example, Murphy, 2019). Ideally, the required data should include high-quality metrics related to the teaching and learning of the targeted students; therefore, it should be more fine-grained than common students' data such as courses taken, teachers, grades and scores (Murphy, 2019). NITI Aayog has acknowledged that several relevant datasets, such as records of student and teacher performance, as well as curricula, are not yet digitized in India (NITI Aayog, 2018). Such data are often only available from existing AI-powered education tools, which is not only comparable to the chicken-or-egg causality dilemma but also linked to several further challenges.

Firstly, this situation could exacerbate algorithmic discrimination by AI in Education systems in India since there are, in general, less data available about disadvantaged rural groups. Moreover, there is often a delay in data that exist in hard copy becoming accessible in digital

formats, which then causes the algorithm to become biased against these groups since they are not part of its 'worldview', as discussed above.

Secondly, the data are often proprietary, in other words, controlled by educational technology (EdTech) companies, and thus not openly available. By contrast, open data 'can be freely used, modified, and shared by anyone for any purpose'[117] and would have multiple advantages, including supporting fairness, accountability and transparency in AI in Education systems (though not fully solving these issues). Therefore, against the backdrop of an ever-increasing deluge of data that are often not findable, accessible, interoperable or reusable (the so-called FAIR principles[118]), several initiatives advocating open data and related resources, not only restricted to AI or education, have been created in the last few years (e.g. UNESCO and IRCAI, upcoming publication). An important example in India is the Open Government Data Platform India,[119] which is maintained by the National Informatics Centre within the Ministry of Electronics and Information Technology of India (MeitY). This platform hosts hundreds of thousands of datasets from central ministries, states and organizations in open access format to be used by anybody, including researchers, start-ups, etc. It has proved to be an excellent source of data on various subjects, including education.

While extensive data sharing through open data is essential for the field of AI in Education, to increase the data pool and subsequently further strengthen countrywide intelligent tutoring systems, the data privacy issues discussed above have to be taken into account, and therefore the performance data of students have to be anonymized.

Another dimension of the shortage of training data is linked to AI-based translation systems, which exist for a number of Indian languages as illustrated in Chapter 4. However, such systems, too, are only as good as the quantity and quality of their training data. The initiative FAIR Forward works on this issue and has noted challenges in finding general-purpose speech datasets in standardized formats and of high quality (GIZ, 2020).

Further concerns about available training data are that they could be manipulated in malicious ways or that they could contribute to digital and data colonialism.

———————————

[117] https://opendefinition.org/
[118] https://www.go-fair.org/fair-principles/
[119] https://data.gov.in

Digital and data colonialism

While the benefits of glocalization were outlined above (see 'Glocalization', Chapter 4), there are also challenges related to scenarios where learning materials, methodologies and educational technologies are transferred from one country to another. The umbrella term coined for such challenges is 'digital or data colonialism', which has many facets and often refers to the Global South and specifically, though to a lesser extent, to India.

One of the central claims of digital or data colonialism is the alleged intention of some countries to provide digital infrastructures to large parts of the world to get control of their data and to monetize them (see, for example, Couldry and Mejias, 2019). The issue of the ownership of AI in Education-related data has been discussed above already, although not yet from the angle of colonialism.

A related issue is that AI in Education systems are often trained with WEIRD data, in other words, data from Western, educated, industrialized, rich and democratic (WEIRD) societies, because such data are easily available and because many EdTech companies are based in these countries. However, such data do not reflect the reality in India and may lead to undesired (in particular, discriminatory) behaviour from AI tools. Therefore, such practices have been denounced by UNESCO as unfair discrimination (UNESCO, 2019c). Issues related to WEIRD data have been

criticized in the field of human psychology previously (Henrich et al., 2010).

Overall, there are concerns that AI in Education systems that have been developed and are successful in one cultural context may not only be ineffective in a different cultural context (Pinkwart, 2016) but may also adversely affect the cultural and linguistic diversity of the country where they are applied.

The protection of cultural diversity through AI in education is hard to achieve if AI in Education systems are only researched and developed in a few countries and then exported to others (Blanchard, 2015). However, this concern may affect other countries more than India since, as this report showcases, various AI in Education approaches have been developed in and for India. Even so, the number of presentations by Indians in international AI in Education conferences appears to be low (Blanchard, 2015).

When it comes to linguistic diversity, risks prevail in India, caused not only by AI in Education but by the internet as a whole, which uses English as the predominant language in India unlike in China, Japan and European countries.[120] While this is also an issue for AI in Education in India, with the majority of systems using English, some AI in Education systems that support other Indian languages have been introduced (see 'Representation of linguistic diversity', Chapter 4).

---

[120] https://indianexpress.com/article/technology/tech-news-technology/how-digital-colonisation-is-still-keeping-internet-away-from-indian-languages-7057030/

Fakes and forgery

While fakes and forgery have been creating problems in interactions between humans for centuries, AI exacerbates the issue as it opens the door for new and much harder-to-detect possibilities. This section introduces two dimensions of the issue: AI-supported fake learning content and AI-supported cheating by students.

The increasing capability to create systems with the malicious intent of manipulating humans through fake content is a serious risk of Artificial Intelligence (see, for example, Chessen, 2018). While this is a critical issue for the overall consumption of internet content and news, it could also become relevant for the field of AI in Education. The opportunity, introduced above, by which glocalized systems would allow for access to learning materials and virtual teaching assistants from anywhere in world carries the risk of seemingly benign learning content being manipulative propaganda in disguise. This can be done through deepfakes, whereby AI systems are able to generate content of increasing quality.

Equally worrying is the fact that AI also offers a variety of means for students to cheat, for which antidotes, also AI-powered, exist in part. One issue is of counterfeit diplomas, credentials or exams created with the help of AI-powered deepfake tools (see, for example, Chessen, 2018). Antidotes include AI solutions that can reveal forged signatures (see, for example, Ribeiro et al., 2011). There are also ways to combat deepfakes that do not involve AI, such as authentication through blockchain technology. UNESCO recommends an 'AI-driven e-portfolio' that keeps records of all the assessment information of a student and ensures authenticity through blockchain technology (UNESCO, 2021e). India is a pioneer in this field since it is one of the few countries in the world that has implemented blockchain-powered educational documents and credentials,[121] using

LegitDoc, a product of Crossforge Solutions, a Bengaluru-based technology company.[122]

Another issue is cheating during exams, whether on-site or remote. The latter gained prominence during the COVID-19 pandemic (see, for example, Noorbehbahani et al., 2022). Malpractices at on-site exams comprise interaction between students moving around and exchanging and copying answers. Malpractices at remote exams include students communicating on the phone or unauthorized persons being in the room and helping students. For on-site exams, The Tamil Nadu Dr. M.G.R. Medical University has considered using AI-supported surveillance to replace the laborious task of analysing closed-circuit television recordings by staff members.[123] For remote exams, Indian companies like HireMee[124] and Eklavvya[125] have developed AI-supported authentication and proctoring solutions. However, this technology may have negative side effects, such as increased test anxiety, as Conijn et al. (2022) have pointed out.

Yet another issue is cheating while writing assignments, for which AI-supported solutions also exist. While plagiarism has been widespread for years and AI-powered anti-plagiarism software exists to counter it (for example, IEMSecure by the Indian company IEMLabs[126]), students may still use AI-supported paraphrasing tools to cover up their plagiarism. This impedes the work of anti-plagiarism software on the one hand, and raises the question of whether this is even cheating or constitutes original work on the other (Rogerson and McCarthy, 2017). Another way that students cheat is to let AI language models like GPT-3 (Generative Pre-trained Transformer-3) write their essays in their entirety (Brown et al., 2020; Dehouche, 2021). No antidote appears to exist for this problem; instead, AI language models are improving constantly.

> While fakes and forgery have been creating problems in interactions between humans for centuries, AI exacerbates the issue as it opens the door for new and much harder-to-detect possibilities.

---

[121] https://www.newswire.com/news/first-blockcerts-issued-in-india-pallavan-school-and-vasant-valley-21072917 and https://www.business-standard.com/content/press-releases-ani/india-becomes-the-fourth-country-to-roll-out-blockchain-powered-educational- documents-121071601003_1.html
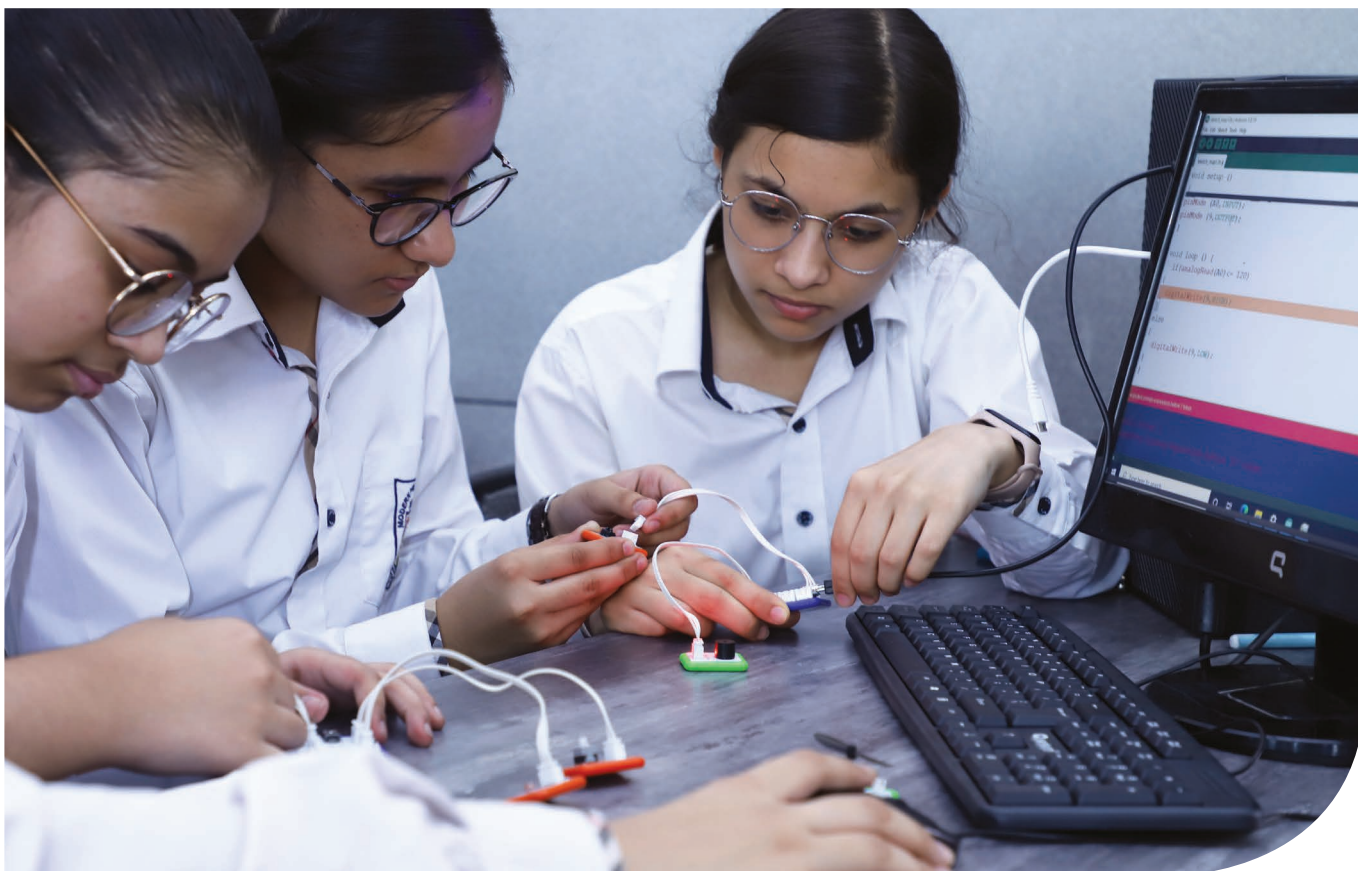
[122] https://www.legitdoc.com/

[123] https://analyticsindiamag.com/medical-university-to-use-ai-for-monitoring-exams/

[124] https://hiremee.co.in/online-exam

[125] https://www.eklavvya.in/online-exam-remote-proctoring.aspx

[126] https://financialsamachar.com/eastern-indias-first-plagiarism-checker-and-artificial-intelligence-softwares-launched/

Above: Students get a hands-on experience of robotics using different types of sensors. Modern Public School, Delhi, India.

Another critical area revolves around data being fed into AI systems with the malicious intent of producing unwanted outputs or reactions from the system.[127] Such attacks have been named 'poison in the well' or 'evasion attacks' and can be made using different methods (see, for example, Lohn, 2021). This is relevant in the context of cheating, as students could attempt to manipulate the scores and grades delivered

by an intelligent tutoring system. For example, Perelman (2020) describes how automated essay scoring (AES) is based on numerical proxies that approximate writing constructs. He developed a so-called BABEL Generator that illustrates how 'students could insert appropriate proxies into any paper, no matter how incoherent the prose, and receive a high score from any one of several AES engines' (p. 1).[128]

---

[127] This must be seen as distinct from unwanted outputs caused by biased and discriminatory data that have been fed into the systems largely negligently.

[128] See also: https://lesperelman.com/writing-assessment-robo-grading/babel-generator/

[129] https://wizklub.com/ and https://inc42.com/startups/edtech-app-augli-banks-on-critical-thinking-superpowers-to-take-indian-kids-beyond-books/

Memorization-based education versus critical thinking

Pedagogy is a complex field with a long history and various approaches. However, current, or at least simple, AI in Education systems focus mostly on one approach, which is memorization-based education through reiterated practise. Such an approach is promising for some subjects, such as foreign languages or history, and can be efficiently implemented through AI algorithms and supported by large amounts of data. Yet there are other desirable skills for students, such as critical thinking, social values, collaboration, creativity and, ultimately,

responsible citizenship, which are harder to grasp through data, harder for AI systems to understand and impossible to teach through a memorization-based approach. Therefore, the challenge consists of developing innovative pedagogical methods to teach the skills above, which can be formalized and implemented by AI in Education systems.

Examples of companies in India aiming to teach critical thinking through AI in Education systems are WizKlub and AugLi.[129]

Changing role for teachers

Chapter 4 outlined opportunities for teachers linked to AI in Education. This section will describe how the changing role of teachers also involves challenges. To begin with, there is the possibility that AI systems will increase human unemployment in many fields. This has often been the case when other technologies were invented to automate processes that were previously performed by humans (see, for example, Korinek and Stiglitz, 2018). Since AI in Education automates various tasks performed by teachers, as well as by administrative staff, there is a risk that the concerned positions will become redundant. However, there are no specific numbers to bolster this fear, as yet, nor is such an outcome desired.

"

Be aware that teachers cannot be displaced by machines, and ensure that their rights and working conditions are protected. (UNESCO, 2019a, p.5).

"

The Beijing Consensus on *Artificial Intelligence and Education*

Often, in the past, new technologies that enabled automation turned out to be blessings in disguise, as the concerned and to-be-replaced tasks were monotonous and unfulfilling for humans.

"

The ambition of many AI developers is to relieve teachers of various burdens (such as monitoring progress and marking assignments), so that they may focus on the human aspects of teaching (such as social engagement, interacting with empathy, and offering personal guidance). (UNESCO, 2021e, p. 27).

"

The UNESCO guide for policy-makers, *AI in Education*

Teachers may also focus on teaching the skills that have been identified above as challenging for AI in Education systems, such as critical thinking, social values, collaboration and creativity. However, the UNESCO guide (2021e) notes that, given the potential of AI, there may be automated options for these remaining tasks in the future.

It is crucial, in any case, to prepare teachers for their changing role, which includes, foremost, capacity-building that allows teachers to work effectively in AI in Education environments. This constitutes a challenge in India as it requires a significant and continuous upskilling effort for teachers (and also administrative staff in educational institutes), especially for those in rural regions, who have a lower level of education to begin with, including a lack of AI literacy (see Chapter 3: AI literacy in India). In this regard, institutional strengthening of lifelong learning for teachers is required to integrate AI in Education in their teaching methodologies and pedagogical tools.

However, this is linked to another dilemma. On the one hand, AI in Education systems must be intuitive enough for teachers to comprehend, and their functionalities must be simple enough to be explained to teachers from any background. On the other hand, there are the challenges of explainable AI, described above, for which a solution is pending (see, for example, Angelov et al., 2021). This is likely to lead to de-motivation as well as trust issues for teachers who may not feel comfortable working with systems they do not understand.

Left: Students take a course on integrating Python with Artificial Intelligence. Modern Public School, Delhi, India.

Issues related to resources and infrastructure

Not only in India, but globally, an essential precondition for the implementation of AI in education is that the necessary infrastructure be in place. This includes essential back-end computing power, access to fast as well as inexpensive or free internet for all targeted learners and teachers, and the availability of necessary devices such as laptops, tablets or smartphones.

An essential precondition for the implementation of AI in education is that the necessary infrastructure be in place. This includes essential back-end computing power, access to fast as well as inexpensive or free internet for all targeted learners and teachers, and the availability of necessary devices such as laptops, tablets or smartphones.

Otherwise, the opportunities of AI-powered educational tools cannot be harnessed. In a scenario in which such infrastructure is only partially in place and only certain groups have the necessary equipment at their disposal, there is the highly undesirable risk of the digital divide widening even further. This, in turn, would constitute a big challenge for India's rural areas.

Some 622 million people use the internet in India (IAMAI and Kantar, 2021), which equals a penetration of 46 per cent and also means that 54 per cent of the population, i.e. 754 million Indians, do not use the internet. Of India's 646 million internet users, 352 million live in rural areas and 294 million in urban areas. This translates to 39 per cent of India's rural population and 62 per cent of India's urban population. However, the growth of internet use in rural areas at 45 per cent is much higher than in urban areas at 28 per cent, as compared with 2019 (Nielsen, 2022). Men constitute approximately 57 per cent of active internet users in urban India and women comprise 43 per cent, while the numbers in rural areas are almost the same: 58 per cent versus 42 per cent. The number of active internet users in India is expected to reach 900 million by 2025 (IAMAI and Kantar, 2021).

However, despite rising internet connectivity and adoption of mobile internet, the digital infrastructure in schools, colleges and for remote education is far from optimal. Almost 100 per cent of active internet users access the internet through mobile phones. Only 17 per cent of active internet users use a personal computer in addition, while only 6 per cent access the internet via tablets or other devices. While schools across India largely lack the basic technological facilities required to adopt any modern AI in Education systems, students in tier-2 and tier-3 cities do not have access to the hardware required to access online classes from home (IAMAI and Kantar, 2021).

Besides hardware, all locations where AI in Education infrastructure is implemented also require human resources. People at such locations should have the skills to maintain these systems and to fix the various technical problems that will inevitably occur, including in students' homes. All too often, new technologies are only used until a problem occurs and then abandoned because qualified staff to fix the problem is not available.

Lastly, AI in Education systems require another resource, which is a large amount of energy, especially during the training phase (Strubell et al., 2019), but also thereafter, to ensure permanent access. If this energy is not produced from renewable sources, AI in Education systems would contribute to an increased carbon footprint.

Significant changes in the education system require monetary support from the government in the form of expenditure on technology and further resources, as required. *The Economic Survey 2021-22* of India shows that the Indian Government's spending on the education sector has decreased in the past ten years, with only 10.4 per cent of total government expenditure allocated to this sector in 2020/21, compared to 11.4 per cent in 2011/12 (Government of India, 2022). As a proportion of its GDP, India's expenditure on education is under 3.5 per cent, compared to a global average of 4.2 per cent.

Without a considerable increase in GDP spending on the education sector, the inclusion and implementation of AI in education will remain very challenging and will impede the education sector's journey towards becoming agile and responsive to the changing needs and requirements of future generations. However, the difficulty that stakeholders face in quantifying the value of their investments in AI in Education systems may impede the spread of AI in education. Therefore, the inclusion of AI in education will have to be justified by a meticulous value case derivation in the face of the massive costs of its implementation. The number of students reachable by AI in Education systems, the number of schools impacted, the magnitude of the gender divide and of socio-economic divides bridged, and, especially, the extent of improved learning outcomes will have to be quantified to justify investments in this sector.

Finally, an option worth considering, especially if the infrastructure constraint is expected to last for a longer time, is to make use of the high prevalence of feature phones, especially among the poorer population, by providing AI-powered learning tools via short messaging service (SMS). This means that basic technologies would be harnessed in a smart way because of the smart technology at the back-end (R. Kumar and W. Holmes, personal communication, May 2022). Since there are about 320 million feature phone users in India,[130] this presents an opportunity, particularly for elderly lifelong learners who may prefer these phones for their simplicity.

Increased inequality and digital divide in education

This section concludes that the challenges outlined in the previous sections could lead to increased inequality and a greater digital divide in education. This is undesirable and would undermine the opportunities described in Chapter 4. To avoid such an outcome, these challenges require attention both globally and also in India, specifically.

Regulatory AI governance frameworks with specific policies for AI in education need to be in place. Related issues of AI accountability and explainability need both Indian and global attention. A whole range of ethical issues must be tackled, including data privacy and ownership as well as algorithmic fairness and biases, which is a country-specific task as discussed. Further challenges, to be addressed by Indian institutions specifically, are the preparedness of teachers, of infrastructure and other resources for AI in education, as well as the availability of training data; all issues that are especially relevant to bridge the digital divide. Further global AI in education-related challenges concern fakes and forgery, digital and data colonialism as well as the specification of pedagogic approaches towards critical and creative thinking in ways that AI systems can emulate.
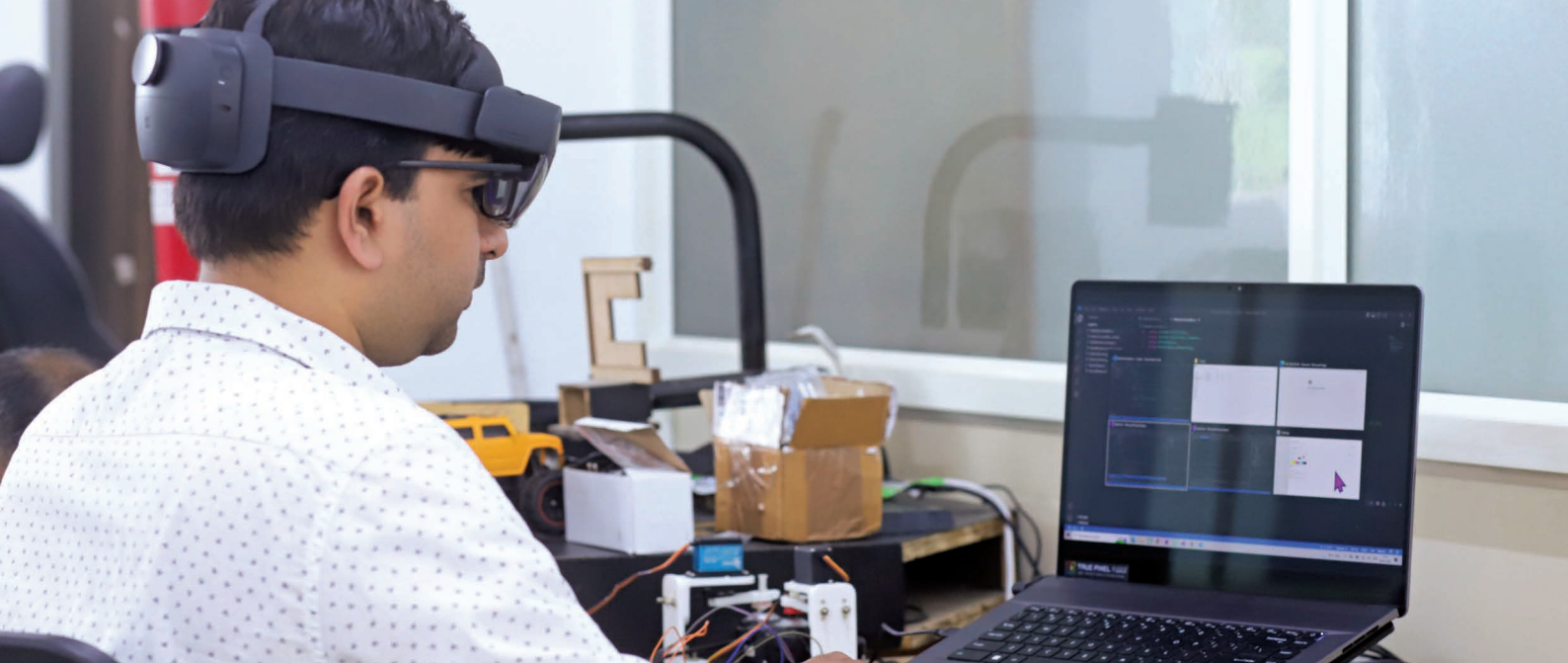
BOX 8

Sketch of a worst-case scenario

- The divide in India has been widened due to AI in education because only certain students, whose families can afford the expensive equipment and who live in areas with high-speed internet, which excludes large areas of rural India, can enjoy the benefits of AI in Education systems.

- The available AI in Education systems are flawed since they are trained insufficiently and predominantly on WEIRD and biased data.

- Predictive analyses for students and the resulting personalized curricula are therefore often inapplicable and equally biased, yet not explainable since the AI in Education systems act like an opaque black box.

- Girls and underprivileged socio-economic groups are disadvantaged in several ways since they endure disproportionate lack of access to AI in Education systems, and those who have access suffer from biased data and algorithms.

- Private, often foreign, corporations own the students' data, collected through omnipresent surveillance, and are not prevented from sharing or misusing them.

- These corporations develop global learning content that is not culturally sensitive, only available in English and focuses on memorization-based education, thus limiting the students' autonomy.

- Teachers are neither trained nor motivated to support AI in Education systems, largely mistrust them and feel redundant at the same time.

- Most students in India do not benefit from AI in Education systems, not even those who have access to them.

Opposite page: Mixed reality-based assistive technology. Indian Institute of Science, Bengaluru, Karnataka, India.

[130] https://www.ibef.org/blogs/indian-smartphone-market-to-reach-a-record-173-million-units-in-2021

Summary

Since AI is a dual-use technology, it also entails challenges and significant risks, some of which concern AI in general, some of which are specific to AI in Education and some of which are specific to India alone.

Globally, the drafting of required AI-related policies is not only lagging behind rapid technological developments in the field, but to what extent AI systems can be governed at all remains an open question, given that they are more advanced than humans and thus often act in ways that are unexplainable, non-transparent or opaque to humans.

Another broad and fundamental field is the Ethics of AI, of which the two aspects of data privacy and ownership, and of algorithmic fairness and biases are particularly relevant for AI in Education. Often, the data of AI in Education systems are owned by private companies, which is undesirable. Moreover, a variety of 'sub-groups of potential Machine Learning (un)fairness in India' (Sambasivan et al., 2021), such as gender, ability and class, may contribute to a biased worldview in AI in Education systems.

A remedy against bias and discrimination would be appropriate training data. However, shortage of training data for AI in Education systems is another challenge in India, which should not be substituted by data from Western, educated, industrialized, rich and democratic (WEIRD) societies, as they do not reflect the reality in India. A solution would be open sharing of anonymized performance data of Indian students to reinforce the training of Indian AI in Education systems.

Further challenges are linked to increasing AI-based fakes and forgery and include a range of AI-supported tools by which students can cheat.

AI in Education systems will also change the role of teachers significantly, which requires massive and continuous upskilling of teachers, while the non-explainability of such systems may lead to demotivation and mistrust.

Suitable resources and infrastructure are an indispensable precondition for overcoming inequality and digital divides through AI in Education systems. Yet there remain severe issues related to resources and infrastructure in India, especially in rural areas.

Conclusions and way forward

The purpose and aim of this State of the Education report is to guide stakeholders on how AI in Education systems could lead to equality, equity and inclusion in education in India as well as to improved learning outcomes. As groundwork, Chapters 4 and 5 described the opportunities and the challenges of AI in Education systems in India. This chapter summarizes these opportunities and challenges and supplements them with a vision for 2030.

Left: A student takes a tour through virtual reality. Modern Public School, Delhi, India.

6 Conclusions and way forward

Chapters 4 and 5 have illustrated that Artificial Intelligence, and thus AI in Education, are double-edged swords, like many other technologies. AI, and AI in Education in particular, can bring amazing benefits to humanity, and especially to a country like India that faces grave issues in education. However, to enjoy the opportunities offered by AI and AI in Education, various challenges must be tackled. As described above, these challenges comprise a diverse range of issues, including lack of policies, governance and accountability, ethical issues concerning data privacy and ownership as well as algorithmic fairness and biases, insufficient or inappropriate training data, and AI-based fakes and forgery. While no solution is in sight nor may ever be devised for some challenges such as the explainability of AI, there are India-specific issues related to resources and infrastructure that can be solved.

As also expressed below in this report's vision for 2030, the conclusion as well as the overall message of this report are positive: that the tremendous potential gains that AI in Education holds for India, in terms of equality, equity and inclusion in education as well as improved learning outcomes, are worth the effort of confronting its challenges.

Table 17 is an overview of potential and existing AI in Education systems and how they could address challenges in the Indian education sector. It aims to illustrate Indian achievements in this field; in other words, the fact that India is on a promising path.[131] The first column indicates the aspect of education covered by a particular type of AI in Education system, that is, whether it is related to learning, teaching, evaluation, school management or mapping and matching of skills, which is further specified in the second column (see Chapter 4). The next column showcases existing AI in Education systems developed by the private sector, academia or the Government of India, some of which are included as case studies in this report (as noted in the fourth column). Finally, the last column refers to the challenges in the education sector in India that were described in Chapter 2 and may be alleviated by these AI in Education systems.

All the AI in Education systems listed in the table require subdisciplines of AI such as natural language processing, knowledge representation, automated reasoning, machine learning and computer vision (Russell and Norvig, 2020). This is one essential difference between AI in Education systems and non-AI educational technology (EdTech) systems. The latter do not use any of the AI subdisciplines listed above and are not included in this report.

Bottom: Students learning robotics and the allied use of technology and electronics. Modern Public School, Delhi, India.

---

[131] Another requirement of AI in Education systems, which is beyond the scope of this report, is the need for quality standards by which to evaluate these systems before adopting them. The evaluation centre EdTech Tulna provides such a service: https://edtechtulna.org/evaluation-centre-catalogue/

The overall message of this report is positive: the tremendous potential gains that AI in Education holds for India, in terms of equality, equity and inclusion in education as well as improved learning outcomes, are worth the effort of confronting its challenges.
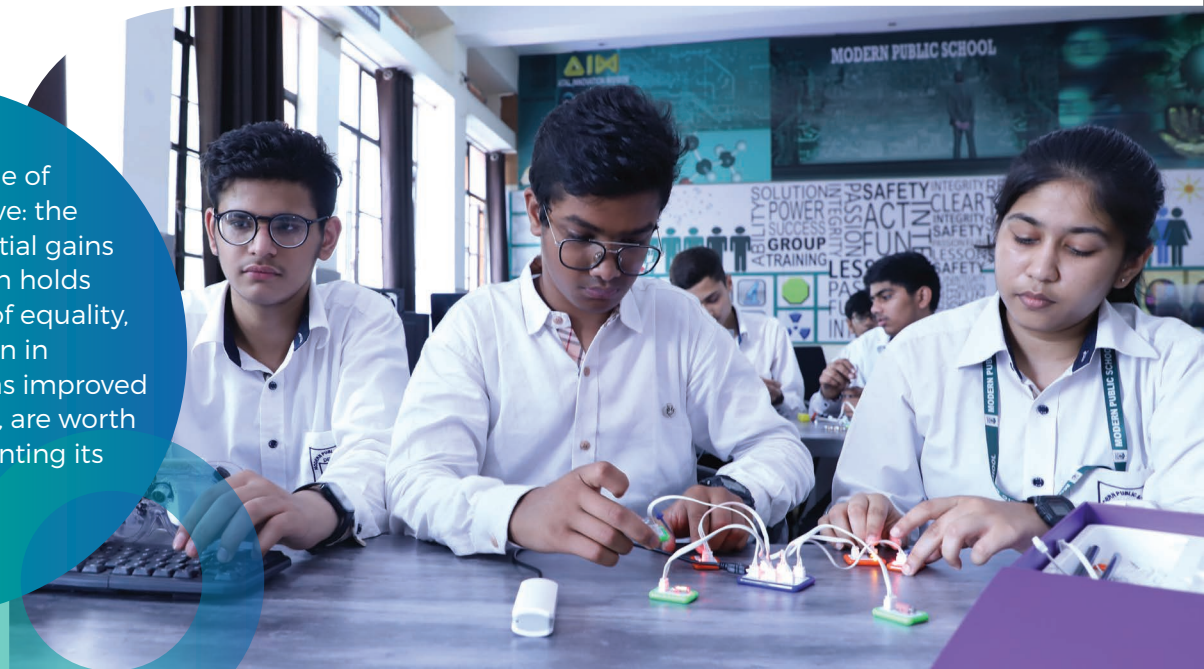
TABLE 17
Overview of potential and existing AI in Education systems and how they could address challenges in the Indian education sector

Categories	Subcategories	AI in Education systems developed by the private sector, academia or the Government of India	Case studies in this report	Challenges in the education sector in India that would be addressed using AI in Education Systems*
Learning (formal)	Personalized intelligent tutoring systems	Chimple	Chimple	• Socio-economic issues • Gender dimension • Teaching issues • Drop-out rate • Linguistic barrier • Digital divide
		Jungroo Learning[132]		
		TARA (Learning Matters)[133]		
		Educational Initiatives' Mindspark	Educational Initiatives' Mindspark	
		Read Along	Read Along	
	Personalized intelligent tutoring systems (for differently abled students)	EYE-D[134]		• Socio-economic issues
		Let's Talk Sign[135]		
		Stamurai[136]		
		Cogniable[137]		
		AttentionKart[138]		
		I-Stem[139]		
		Metanoa[140]		
		Eye tracking-based assistive technology for Indians with speech and motor impairment (IISc, Bengaluru)	Eye tracking-based assistive technology for Indians with speech and motor impairment (IISc, Bengaluru)	
Learning (formal and informal)	AI-based translation systems for linguistic minorities	Project UDAAN (IIT Bombay)[141]		• Socio-economic issues • Linguistic barrier
		Bhasha (Microsoft Indic Language Input Tool – ILIT)[142]		
		Devnagri[143]		
		AI4Bharat (IIT Madras)[144]		
		AICTE Translation Automation Artificial Intelligence Tool[145]		
Learning (informal)	AI chatbots	Bol Behan[146]	Bol Behan	• Socio-economic issues • Gender inequalities • Digital divide
		SnehAI[147]		
Teaching	Automation of tasks of teachers, e.g. developing curricula, educational materials and assignments	DeepGrade (Smartail)		• Teaching issues
		Jungroo Learning		
		TARA (Learning Matters)		
	Routine interaction with students/frequently asked questions	TARA (Learning Matters)		• Teaching issues

■ Private sector   ■ Academia   ■ Government of India   *(see Chapter 2: Introduction, pp. 30-32)

[132] https://jungroo.com/
[133] https://learningmatters.ai/
[134] https://eye-d.in/
[135] https://www.letstalksign.org/index.php
[136] https://stamurai.com/
[137] https://cogniable.tech/
[138] https://www.attentionkart.com/
[139] https://www.inclusivestem.org/index.html
[140] https://metanoa.ai/
[141] https://www.udaanproject.org/
[142] https://www.microsoft.com/en-in/bhashaindia/
[143] https://devnagri.com/
[144] https://ai4bharat.org/
[145] https://translation.aicte-india.org/
[146] https://chhaajaa.com/chhaa-jaa-peshkash/bol-behen/
[147] https://snehai.org/

Categories	Subcategories	AI in Education systems developed by the private sector, academia or the Government of India	Case studies in this report	Challenges in the education sector in India that would be addressed using AI in Education Systems*
Evaluation	Tracking learning outcomes, assessing competencies, and predictive analysis	Jungroo Learning		• Teaching issues • Drop-out rate
		Chimple		
		Educational Initiatives' Mindspark		
		Read Along		
		Microsoft's Azure/Cortana Analytics Suite (CAS) + Vidyarthi Nestham (Andhra Pradesh Government)		
	Grading of assignments and essays	DeepGrade (Smartail)[148]		• Teaching issues
		RealLearning AI		
		Jungroo Learning		
	Detecting plagiarism and cheating	LegitDoc[149]		• Teaching issues
		IEMSecure[150]		
School management	Management of school administration and premises	Skugal[151]		
		National Digital Education Architecture – Vidya Samiksha Kendra (NDEAR-VSK)	National Digital Education Architecture – Vidya Samiksha Kendra (NDEAR-VSK)	
	Surveillance of school premises	CamfyVision[152]		
	Biometric attendance systems	Skugal		
		Attendance system for Assam by RailTel Corporation[153]		
		AI-driven attendance systems (Assam, Tamil Nadu, Uttar Pradesh)	AI-driven attendance systems (Assam, Tamil Nadu, Uttar Pradesh)	
	Detecting drop-out risk	AI-driven drop-out risk detection system (Andhra Pradesh)	AI-driven drop-out risk detection system (Andhra Pradesh)	• Drop-out rate
		National Digital Education Architecture – Vidya Samiksha Kendra (NDEAR-VSK)	National Digital Education Architecture – Vidya Samiksha Kendra (NDEAR-VSK)	
	Remote authentication and proctoring of students	ProEx (HireMee)[154]		
		Eklavvya[155]		
		Digiproctor[156]		
Mapping and matching of skills	Identification of potentially emerging job profiles via big data about vacancies	Skill-X (iNurture Education Solutions)[157]	AI-supported anticipation of required skills in the labour market	
		Mindler[158]		

Source: Compiled by authors

Private sector   Academia   Government of India   *(see Chapter 2: Introduction, pp. 30-32)

[148] https://www.smartail.ai/deepgrade/
[149] https://www.legitdoc.com/
[150] https://www.iemsecure.com/
[151] https://skugal.com/
[152] https://www.camfyvision.com/
[153] https://indiaai.gov.in/news/
ai-based-attendance-system-implemented-for-govt-schools-in-assam
[154] https://hiremee.co.in/online-exam
[155] https://www.eklavvya.com/
[156] https://www.digiproctor.com/home/
[157] https://inurture.co.in/krackin-skillx/
[158] https://www.mindler.com/

Of the many AI in Education systems being developed, and in terms of coverage in this report, personalized intelligent tutoring systems within the category of formal learning may be considered the centrepiece. Personalized intelligent tutoring systems could be supplemented by specialized systems that support informal learning, teaching, evaluation, school management as well as mapping and matching of skills, which are also illustrated in Table 17.

If implemented broadly in India, personalized intelligent tutoring systems are likely to be disruptive (as are AI applications in many other fields) but in a positive way, since intelligent tutoring systems offer wide-ranging opportunities, as described above, and have the potential to address many of the challenges in the education sector in India as indicated in Table 17. Besides harnessing these opportunities, however, all the challenges outlined in Chapter 5 must be tackled too, which leads to the vision below.

Vision for 2030

This report's vision and aspiration is that responsible and human-centred application of AI in the education sector in India will have made significant progress by 2030. AI in Education systems will have contributed considerably to efforts to achieve SDG 4 in India and will have helped address issues related to equality, equity and inclusion in education.

This will have been accompanied by improved learning outcomes since personalized intelligent tutoring systems will have replaced the

obstructive one-size-fits-all approach and will design individually optimized curricula based on a deluge of data and AI-powered detection of patterns and trends that are beyond the capabilities of human teachers to process.

Preconditions to fulfil this vision are that the opportunities offered by AI in Education systems, and by intelligent tutoring systems in particular, are harnessed in India (that is, that the best-case scenario outlined in Chapter 4 is supported), while all the challenges of these systems are addressed (that is, that the worst-case scenario outlined in Chapter 5 is prevented).

As this report has discussed, there are complex challenges and risks related to AI that require urgent attention, globally and in India in particular, while the likelihood of solving them soon or ever cannot be predicted.

To support this vision, we have developed ten recommendations that will be detailed in Chapter 7.

> **By 2030, AI in Education systems will have contributed considerably to efforts to achieve SDG 4 in India and will have helped address issues related to equality, equity and inclusion in education.**

SDG 4 QUALITY EDUCATION

BOX 9

Recommendations from the Beijing Consensus on AI and Education

The Beijing Consensus on AI and Education discussed the opportunities and challenges of AI in Education and developed the following recommendations for governments and other stakeholders among UNESCO's Member States (UNESCO, 2019a, p. 44):

- Planning AI-in-education policies.
- Using AI for education management and delivery.
- Using AI to empower teaching and teachers.
- Using AI for learning and learning assessment.

- Developing values and skills for life and work in the AI era.
- Using AI to offer lifelong learning opportunities for all.
- Promoting equitable and inclusive use of AI in education.
- Facilitating gender-equitable AI.
- Ensuring ethical, transparent and auditable use of education data and algorithms.
- Monitoring, evaluating and researching the impacts of AI applications in education.

Recommendations

This chapter presents ten recommendations to harness the opportunities and address the challenges outlined in this report. As discussed in previous chapters, several challenges related to Artificial Intelligence are very complex and lack applicable solutions for now. Therefore, the following list of recommendations focuses on essential and mostly feasible actions by which the vision of equality, equity and inclusion in education for India by 2030, as well as of improved learning outcomes through personalized intelligent tutoring systems, may become a reality.

Left: Haptic gloves are used for virtual reality and robotics. Amrita Vishwa Vidyapeetham, Kerala, India.

Recommendations

Recommendation 1
Consider the Ethics of Artificial Intelligence in Education as an utmost priority.

The Ethics of Artificial Intelligence is a complex and evolving field. At the same time, it is uncertain if policies on the Ethics of Artificial Intelligence can be implemented, given that Artificial Intelligence systems are already much more advanced than humans in many fields; a development that is likely to multiply in the future. In other words, Artificial Intelligence systems may not comply with policies imposed by humans. Nevertheless, as it is related to the critical field of education, all concerned stakeholders should treat the ethics of evolving Artificial Intelligence in Education with utmost priority. This involves diverse aspects such as privacy, fairness, transparency, autonomy, trust and dignity, among others.

Recommendation 2
Rapidly provide an overall regulatory framework for Artificial Intelligence in Education.

Rapid technological developments in Artificial Intelligence in Education must not outpace the development of policies to ensure that Artificial Intelligence in Education contributes, through a humanistic and ethical approach, to equality, equity and inclusion in education in India. These policies must also have a much-needed special focus on differently abled students so as to improve the learning outcomes and well-being of these children, thus leading to the achievement of the targets of Sustainable Development Goal (SDG) 4 on quality education. Moreover, it is critical that a wide range of relevant multidisciplinary researchers be involved in the development of an overall regulatory Artificial Intelligence in Education framework.

Below: Colour-coded keys help visually or motor-impaired individuals use computers. Amar Jyoti School, Delhi, India.

Above: Artificial Intelligence being used to track the movement of fishermen and provide them connectivity while they are at sea. Amrita Vishwa Vidyapeetham, Kerala, India.

Recommendation 3
Create effective public-private partnerships.

The involvement of the Indian private sector in Artificial Intelligence in Education is unprecedented, which is welcome since the public sector does not have the capacity to develop a full range of education products using Artificial Intelligence. However, this requires cooperation as well as regulation through effective public-private partnerships in the following areas, at the least: to supervise the private sector's management of data ownership, privacy and sharing, as well as other ethical issues (see also Recommendation 1); and to encourage the private sector to focus on personalized intelligent tutoring systems in particular as they constitute the most promising opportunity in the Artificial Intelligence in Education field.

Recommendation 4
Ensure that all students and teachers have access to the latest technology.

Highspeed internet as well as appropriate infrastructure and devices are prerequisites to harness the opportunities of Artificial Intelligence in Education systems in India. It is only if online access to Artificial Intelligence in Education systems for all students, including lifelong learners, is ensured that the foundation for Artificial Intelligence in Education-supported equality, equity and inclusion can be laid out. Efforts should also be made to include remote areas of India. Appropriate access must include differently abled students in particular, since this is an area where Artificial Intelligence in Education systems could add significant value to the learning experience.

Above: Online platforms teach students how to use AI tools. Modern Public School, Delhi, India.

Recommendation 5
Expand AI literacy efforts.

While discussing AI literacy as a complementary subject to AI-powered education tools, this report has demonstrated that, overall, India seems to be well on track when it comes to AI literacy. However, efforts should be strengthened concerning two aspects of AI literacy: inclusion and the Ethics of Artificial Intelligence. Currently, girls, women and disadvantaged socio-economic groups, including differently abled students,

have less opportunities to become AI literate. Moreover, the ethics as well as the social facets of Artificial Intelligence should be considered to be as important as the technological aspects of AI literacy. The various aspects of the Ethics of Artificial Intelligence should be taught even to those who are not interested or skilled in programming, since it is likely that everyone will have to deal with Artificial Intelligence in the future.

Recommendation 6
Attempt to correct algorithmic biases and the resulting discrimination.

From the range of issues related to Artificial Intelligence, the bias in algorithmic decision-making can be considered the most severe since it has the potential to prevent equality, equity and inclusion in education in India. Algorithmic bias has been examined in Western countries for some time, yet it was only recently acknowledged that this analytical approach cannot be directly transferred to the Indian context due to the

different prevailing 'axes of potential Machine Learning (un)fairness in India'. These axes and their impact on algorithmic bias should be examined carefully through a multidisciplinary approach involving all relevant stakeholders, with the objective to eliminate biases in Artificial Intelligence algorithms and to let fairness prevail in Artificial Intelligence in Education systems in India.
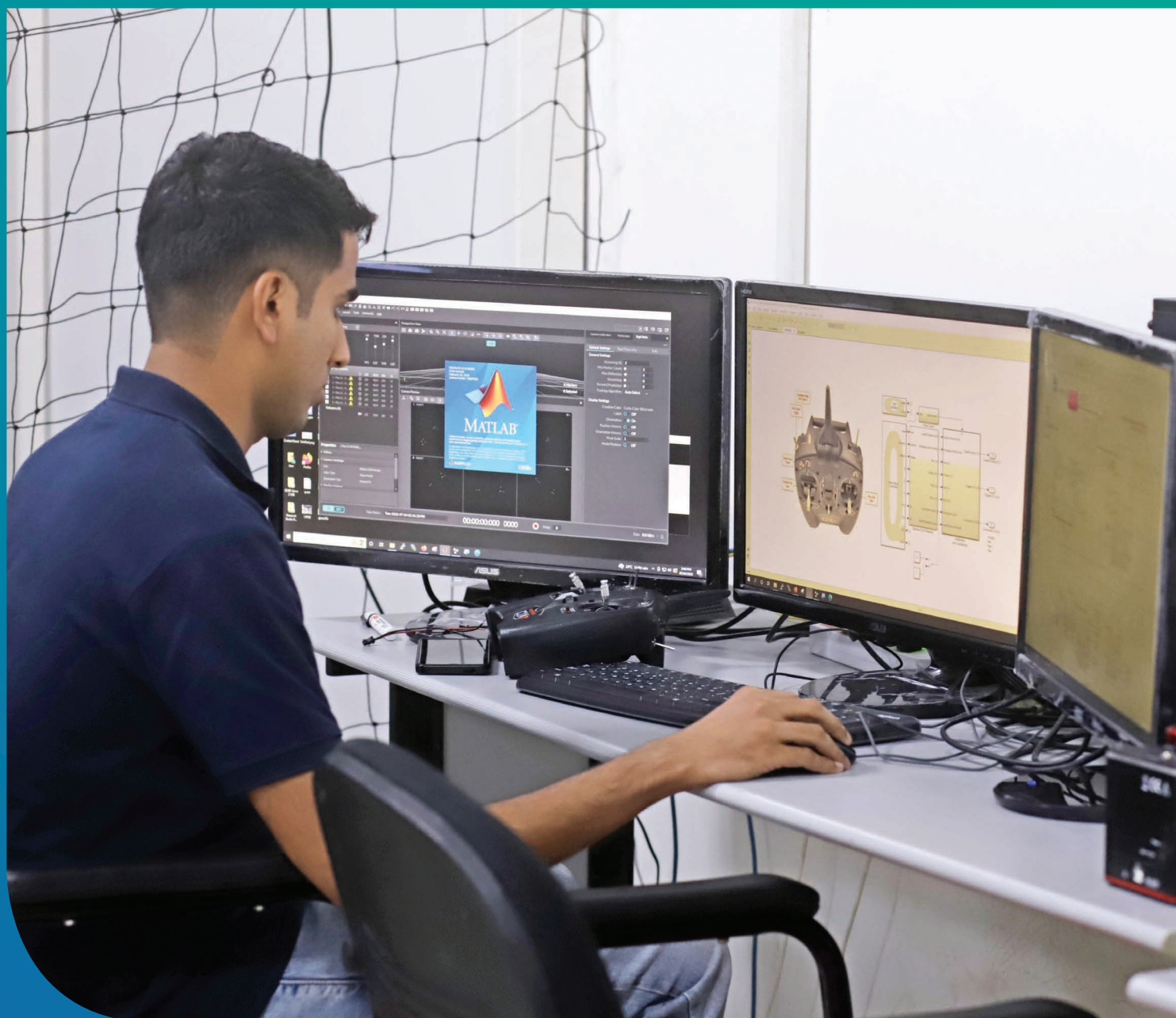
Recommendation 7
Improve public trust in Artificial Intelligence.

Current Artificial Intelligence in Education systems have often arrived at results and conclusions in ways that are unexplainable, non-transparent and opaque to humans. This does not only influence how readily stakeholders trust these systems, but also poses problems regarding the accountability of the systems. To create Artificial Intelligence in Education systems that produce immediately understandable results is a challenging and perhaps unsolvable task, given that Artificial Intelligence systems are much more advanced than humans. However, considering the importance of the task, research efforts in India should focus on building trust in and supporting the transparency and accountability of Artificial Intelligence in Education products. One way of doing this would be to align Artificial Intelligence in Education efforts with research on the science of learning, which includes the scientific validation of the pedagogical models of Artificial Intelligence in Education systems. This requires a call for further research on how Artificial Intelligence can augment human cognition and how it can optimize learning and teaching processes.

Below: A young researcher works on autonomous landmark detection by mobile robots. International Institute of Information Technology, Bengaluru, Karnataka, India.

Above: Two schoolgirls write a computer program together in an AI Skills Lab. Dr Rajendra Prasad Kendriya Vidyalaya, New Delhi, India.

Recommendation 8
Request the private sector to better involve students and educationists in developing AI products.

The activities and technical capacities of the Indian private sector in education provide opportunities to develop Artificial Intelligence systems. Moreover, it is critical that the companies involve teachers, students, lifelong learners, parents as well as multidisciplinary researchers in the development of these products, to ensure that their needs are met and that their diverse expertise is considered. This must include, in particular, the needs of differently abled students.

Recommendation 9
Place ownership of data with the students.

Data privacy for students is one of the biggest concerns related to Artificial Intelligence in Education systems. Private companies must not monetize data from students, which applies to both raw and inferred data. Instead, data should be owned by the students and be used by the companies only for two purposes: to assess the individual student to whom the data belong, and to share them in anonymized formats as training data to further strengthen countrywide intelligent tutoring systems. The latter point is critical since access to training data in terms of quality as well as quantity has been identified as a major challenge for Artificial Intelligence in Education systems in India. Moreover, private companies should not use either foreign training data or biased data for their intelligent tutoring systems.

Recommendation 10
Embrace the versatility of Artificial Intelligence in Education systems.

For students and lifelong learners in India, and especially for those who were previously disadvantaged, Artificial Intelligence in Education systems offer a range of opportunities towards equality, equity and inclusion in education in India. Some of the main reasons for students and lifelong learners to benefit from Artificial Intelligence in Education systems include the possibility of receiving tailored and diverse learning materials based on real-time assessments. This would replace the prevalent one-size-fits-all approach, and time- and location-independent access would enhance the classroom learning experience. Especially for differently abled students, appropriate Artificial Intelligence in Education systems may potentially bring about much needed positive results.

Artificial Intelligence in Education systems offer a range of opportunities for teachers in India, despite teachers' scepticism towards new technologies and given the ambiguity of the current systems. The two main benefits of applying Artificial Intelligence in Education systems are: teachers' time and efforts are saved and liberated by the automatization of routine and usually unsatisfying tasks; and the socio-emotional, creative, empathetic and inspirational aspects of teaching regain their place as the core and the most fulfilling aspects of the teaching profession. Furthermore, trust in these systems could be increased through explainability (see also Recommendation 6).

Below: A virtual reality-based flight simulator with eye gaze-controlled multi-function displays (MFDs). Indian Institute of Science, Bengaluru, Karnataka, India.

Glossary

Algorithm: A set of mathematical instructions or rules that, especially if given to a computer, will help to calculate an answer to a problem.[159]

Artificial general intelligence: An AI 'that is broad in the way that human cognitive systems are broad, that can do different kinds of tasks well, and that really simulates the breadth of the human intellect, rather than focusing on more specific or narrower types of tasks.'[160] See also Narrow AI.

Artificial intelligence (AI): Since intelligence is defined as 'an agent's ability to achieve goals in a wide range of environments' (Legg and Hutter 2007, p. 12, see below), AI is intelligence where the agent is not a living being, but a machine.

Artificial neural network (ANN): 'Networks of interconnected data sets, based on a vastly simplified understanding of brain neural networks.' (Luckin et al., 2016, p. 25).

Automated Reasoning: This refers to the capability of a computer to use stored information for answering questions and for drawing new conclusions (Russell & Norvig, 2020).

Bias: The action of supporting or opposing a particular person or thing in an unfair way.[161]

Big data: Very large sets of data that are produced by people using the internet, and that can only be stored, understood and used with the help of special tools and methods.[162]

Black box: A system or process that uses information to produce a particular set of results, but that works in a way that is secret or difficult to understand.[163]

Blockchain: A digital database containing information (such as records of financial transactions) that can be simultaneously used and shared within a large decentralized, publicly accessible network.[164]

Chatbot: A computer program, often AI-powered, designed to have a conversation with a human being, especially over the internet.[165]

Computer Vision: This refers to the capability of a computer to perceive objects (Russell and Norvig, 2020).

Deepfake: An image or recording that has been convincingly altered and manipulated to misrepresent someone as doing or saying something that was not actually done or said.[166]

Deep learning: 'Refers to ANNs that comprise multiple intermediary layers. It is this approach that has led to many of the recent remarkable applications of AI'. (UNESCO, 2021e, p. 9).

Below: A student testing an AI-driven 3D printer. Modern Public School, Delhi, India.

---

159 https://dictionary.cambridge.org/dictionary/english/algorithm

160 https://www.techopedia.com/definition/31618/artificial-general-intelligence-agi

161 https://dictionary.cambridge.org/dictionary/english/bias

162 https://dictionary.cambridge.org/dictionary/english/big-data

163 https://dictionary.cambridge.org/dictionary/english/black-box

164 https://www.merriam-webster.com/dictionary/blockchain

165 https://dictionary.cambridge.org/dictionary/english/chatbot

166 https://www.merriam-webster.com/dictionary/deepfake

Above: Emerging technologies like AI have created a buzz in the mind of many students and they continue to tinker with new ideas and develop products that benefit society. Indian Institute of Science, Bengaluru, Karnataka, India.

Educational data mining: 'The development and use of methods to analyse and interpret the "big data" that comes from computer-based learning systems and from school, college, or university administrative and management systems.' (Luckin et al., 2016, p. 24).

Educational technology (EdTech): 'Technologies – including hardware, software and digital content – designed or appropriated for (any) educational purpose.' (Hennessy et al., 2021. p. 8). A distinction can be made between AI-powered EdTech and not AI-powered EdTech.

Intelligence: 'Intelligence measures an agent's ability to achieve goals in a wide range of environments'. Legg and Hutter (2007, p. 12).

Intelligent tutoring system (ITS): 'ITS use AI techniques to simulate one-to-one human tutoring, delivering learning activities best matched to a learner's cognitive needs and providing targeted and timely feedback' (Luckin et al., 2016, p. 24).

Knowledge representation: This refers to the capability of a computer to store what it knows and perceives (Russell and Norvig, 2020).

Machine learning: This refers to the capabilities of a computer to adapt to new circumstances and to detect and extrapolate patterns (Russell and Norvig, 2020).

Narrow AI: An AI 'designed to perform a single task, and any knowledge gained from performing that task will not automatically be applied to other tasks.'[167]

Natural language processing (NLP): This refers to the capability of a computer to communicate successfully in a human language (Russell and Norvig, 2020).

Open educational resources: Learning, teaching and research materials in any format and medium that reside in the public domain.[168]

Robotics: This refers to the capabilities of a computer to manipulate objects and to move them around (Russell and Norvig, 2020).

Strong AI: See Artificial general intelligence.

Weak AI: See Narrow AI.

---

[167] https://www.techopedia.com/definition/32874/narrow-artificial-intelligence-narrow-ai

[168] https://www.unesco.org/en/communication-information/open-solutions/open-educational-resources

References

Accenture. 2017. *Rewire For Success Boosting India's AIQ*. https://www.accenture.com/_acnmedia/PDF-153/Accenture-AI-For-Economic-Growth-India.pdf (Accessed 30 August 2022.)

Aguiar, E., Lakkaraju, H., Bhanpuri, N., Miller, D., Yuhas, B. and Addison K. L. 2015. Who, When, and Why: A Machine Learning Approach to Prioritizing Students at Risk of not Graduating High School on Time. *Proceedings of the Fifth International Conference on Learning Analytics And Knowledge*, pp. 93-102. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.725.9316&rep=rep1&type=pdf (Accessed 31 August 2022.)

Akgun, S. and Greenhow, C. 2021. Artificial Intelligence in Education: Addressing Ethical Challenges in K-12 Settings. *AI and Ethics*, pp. 1-10. https://link.springer.com/article/10.1007/s43681-021-00096-7 (Accessed 30 August 2022.)

Analytics India Magazine and Jigsaw Academy. 2020. *State of Artificial Intelligence in India – 2020*. https://analyticsindiamag.com/report-state-of-artificial-intelligence-in-india-2020/ (Accessed 30 August 2022.)

Anderson, J. R., Boyle, C. F., Corbett, A. T. and Lewis, M.W. 1990. Cognitive modeling and intelligent tutoring. *Artificial intelligence*, Vol. 42, No. 1, pp. 7-49.

Angelov, P. P., Soares, E. A., Jiang, R., Arnold, N. I. and Atkinson, P. M. 2021. Explainable artificial intelligence: an analytical review. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, Vol. 11, No. 5, pp. 1-13.

ASER Centre. 2021. Annual Status of Education Report (Rural). http://img.asercentre.org/docs/aser2021forweb.pdf (Accessed 30 August 2022.)

Baker, T., Smith, L., and Anissa, N. 2019. *Educ-AI-tion Rebooted? Exploring the future of artificial intelligence in schools and colleges*. NESTA. https://media.nesta.org.uk/documents/Future_of_AI_and_education_v5_WEB.pdf (Accessed 30 August 2022.)

Blanchard, E. G. 2015. Socio-cultural imbalances in AIED research: investigations, implications and opportunities. *International Journal of Artificial Intelligence in Education*, Vol. 25, No. 2, pp. 204-28. https://link.springer.com/article/10.1007/s40593-014-0027-7 (Accessed 30 August 2022.)

Bostrom, N. 2014. *Superintelligence: Paths, Dangers, Strategies*. Oxford, Oxford University Press.

Brown, T., Mann, B., Ryder, N., Subbiah, M., Kaplan, J. D., Dhariwal, P., Neelakantan, A., Shyam, P., Sastry, G., Askell, A. and Agarwal, S. 2020. Language models are few-shot learners. *Advances in neural information processing systems*, Vol. 33, pp.1877-1901. https://proceedings.neurips.cc/paper/2020/file/1457c0d6bfcb4967418bfb8ac142f64a-Paper.pdf (Accessed 31 August 2022.)

Bryant, J., Heitz, C., Sanghvi, S. and Wagle, D. 2020. *How Artificial Intelligence Will Impact K-12 Teachers*. McKinsey & Company. https://www.mckinsey.com/~/media/McKinsey/Industries/Public%20and%20Social%20Sector/Our%20Insights/How%20artificial%20intelligence%20will%20impact%20K%2012%20teachers/How-artificial-intelligence-will-impact-K-12-teachers.pdf (Accessed 30 August 2022.)

Burns, M. 2021. *Technology in Education*. Paper commissioned for the 2023 Global Education Monitoring Report. https://unesdoc.unesco.org/ark:/48223/pf0000378951/PDF/378951eng.pdf.multi (Accessed 30 August 2022.)

Cambridge Assessment International Education. 2018. *Syllabus Cambridge IGCSE. Information and Communication Technology 0417*. https://www.cambridgeinternational.org/Images/466435-2020-2022-syllabus.pdf (Accessed 30 August 2022.)

CARE India. 2021. *Policy Brief on Girls' Education*. https://www.careindia.org/wp-content/uploads/2021/05/Policy-Brief-Girls-Education.pdf (Accessed 30 August 2022.)

Cave, S. and ÓhÉigeartaigh, S. S. 2018. An AI race for strategic advantage: rhetoric and risks. *Proceedings of the 2018 AAAI/ACM Conference on AI, Ethics, and Society*, pp. 36-40.

CBSE and Intel. 2019a. *Artificial Intelligence Integration for School Curriculum*. http://cbseacademic.nic.in/web_material/Curriculum20/AI_Integration_Manual_Introduction.pdf (Accessed 30 August 2022.)

CBSE and Intel. 2019b. *Artificial Intelligence Curriculum*. Class 9. Facilitator Handbook. https://cbseacademic.nic.in/web_material/

Curriculum20/AI_Curriculum_Handbook.pdf (Accessed 30 August 2022.)

Chahal, H., Abdulla, S., Murdick, J. and Rahkovsky, I. 2021. *Mapping India's AI Potential*. CSET Data Brief. https://cset.georgetown.edu/wp-content/uploads/CSET-Mapping-Indias-AI-Potential-1.pdf (Accessed 30 August 2022.)

Chen, L., Chen, P. and Lin, Z. 2020. Artificial intelligence in education: a review. *IEEE Access*, Vol. 8, pp. 75264-78. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9069875 (Accessed 31 August 2022.)

Chessen, M. 2018. The MADCOM future: how artificial intelligence will enhance computational propaganda, reprogram human culture, and threaten democracy… and what can be done about it. Roman V. Yampolskiy (ed.), *Artificial Intelligence Safety and Security*, 1st edn, New York, Chapman and Hall/CRC, pp. 127-44.

Conijn, R., Kleingeld, A., Matzat, U. and Snijders, C. 2022. The fear of big brother: the potential negative side-effects of proctored exams. *Journal of Computer Assisted Learning*. https://onlinelibrary.wiley.com/doi/pdf/10.1111/jcal.12651 (Accessed 31 August 2022.)

Couldry, N., and Mejias, U. A. 2019. Data colonialism: rethinking big data's relation to the contemporary subject. *Television & New Media*, Vol. 20, No. 4, pp. 336-49. https://eprints.lse.ac.uk/89511/1/Couldry_Data-colonialism_Accepted.pdf (Accessed 30 August 2022.)

Dafoe, A. 2018. *AI Governance: A Research Agenda*. Oxford, Governance of AI Program, Future of Humanity Institute, University of Oxford. https://www.fhi.ox.ac.uk/wp-content/uploads/GovAI-Agenda.pdf (Accessed 30 August 2022.)

Daugherty, P. R. and Wilson, H. J. 2018. Human+machine: reimagining work in the age of AI. *Harvard Business Press*. https://cdn.porchlightbooks.com/assets/ChangeThis/manifesto/163.03.HumanMachine/pdf/163.03.HumanMachine.pdf (Accessed 31 August 2022.)

de la Higuera, C. 2019. *A Report about Education, Training Teachers and Learning Artificial Intelligence: Overview of Key Issues*. https://www.k4all.org/wp-content/uploads/2019/11/Teaching_AI-report_09072019.pdf (Accessed 30 August 2022.)

DEF and Centre for Catalysing Change. 2021. *Bridging the Digital Divide for Girls in India*. https://www.c3india.org/uploads/news/Bridging_the_Digital_Divide-Policy_Brief_2021_(website)1.pdf (Accessed 30 August 2022.)

Dehouche, N., 2021. Plagiarism in the age of massive Generative Pre-trained Transformers (GPT-3). *Ethics in Science and Environmental Politics*, Vol. 21, pp.17-23. https://www.int-res.com/articles/esep2021/21/e021p017.pdf (Accessed 30 August 2022.)

DFID. 2005. *Girls' education*: Towards a Better Future for All. https://www2.ohchr.org/english/issues/development/docs/girlseducation.pdf (Accessed 30 August 2022.)

Duraiappah, A. and Shefet, D. (n.d.) Artificial intelligence and education – why learning data should belong to all of us. *TeachWire*. https://www.teachwire.net/news/artificial-intelligence-and-education-why-learning-data-should-belong-to-all-of-us (Accessed 5 May 2022)

Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., … and Williams, M. D. 2019. Artificial Intelligence (AI): multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, Vol. 57, 101994. https://www.sciencedirect.com/science/article/abs/pii/S026840121930917X (Accessed 30 August 2022.)

GIZ. 2020. A Study on *Open Voice Data in Indian Languages*.

Government of India. 2022. *Economic Survey 2021-22*. https://www.indiabudget.gov.in/economicsurvey/doc/echapter.pdf (Accessed 30 August 2022.)

Government of Tamil Nadu. 2020. *Tamil Nadu Safe & Ethical Artificial Intelligence Policy 2022*. https://elcot.in/sites/default/files/AIPolicy2020.pdf (Accessed 30 August 2022.)

Haenlein, M. and Kaplan, A. 2019. A brief history of artificial intelligence: on the past, present, and future of artificial intelligence. *California Management Review*, Vol. 61, No. 4, pp. 5-14. https://www.researchgate.net/profile/Michael-Haenlein/publication/334539401_A_Brief_History_of_Artificial_Intelligence_On_the_Past_Present_and_Future_of_Artificial_Intelligence/links/60cd82e5a6fdcc01d482dc23/A-Brief-History-of-Artificial-Intelligence-On-the-Past-Present-and-Future-of-Artificial-Intelligence.pdf (Accessed 31 August 2022.)

Handforth, C. and Bertermann, K. 2018. *How Girl Effect Built a Chatbot*. https://www.researchgate.net/publication/329924130_How_Girl_Effect_built_a_chatbot (Accessed 30 August 2022.)

Hennessy, S., Jordan, K., Wagner, D. and Ed Tech Hub Team. 2021. *Problem Analysis and Focus of EdTech Hub's Work: Technology in Education in Low- and Middle-income Countries*. Working Paper 7. EdTech Hub. https://www.repository.cam.ac.uk/bitstream/handle/1810/319313/Problem%20Analysis_Technology%20in%20Education_Revised%20Final_1.pdf?sequence=1 (Accessed 4 September 2022.)

Henrich, J., Heine, S. J. and Norenzayan, A. 2010. Most people are not WEIRD. *Nature*, Vol. 466, No. 7302, pp. 29. https://www.nature.com/articles/466029a (Accessed 30 August 2022.)

Himeur, Y., Sohail, S. S., Bensaali, F., Amira, A. and Alazab, M. 2022. Latest trends of security and privacy in recommender systems: a comprehensive review and future perspectives. *Computers & Security*, Vol.118, pp. 102746.

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I. and Koedinger, K. R. 2021. Ethics of AI in Education: towards a community-wide framework. *International Journal of Artificial Intelligence in Education*, pp. 1-23. https://link.springer.com/content/pdf/10.1007/s40593-021-00239-1.pdf (Accessed 30 August 2022.)

Huang, T., Arnold, Z. and Zwetsloot, R. 2020. *Most of America's 'Most Promising' AI Startups Have Immigrant Founders*. CSET Data Brief. https://cset.georgetown.edu/wp-content/uploads/CSET-Most-of-Americas-Most-Promising-AI-Startups-Have-Immigrant-Founders.pdf (Accessed 30 August 2022.)

Hwang, G. J., Xie, H., Wah, B. W. and Gašević, D. 2020. Vision, challenges, roles and research issues of Artificial Intelligence in Education. *Computers and Education: Artificial Intelligence*, Vol. 1, p. 100001.

IAMAI and Kantar. 2021. *Internet Adoption in India*. ICUBE 2020. https://images.assettype.com/afaqs/2021-06/b9a3220f-ae2f-43db-a0b4-36a372b243c4/KANTAR_ICUBE_2020_Report_C1.pdf (Accessed 30 August 2022.)

Indiaai. 2021. *21 women in '21*. https://indiaai.s3.ap-south-1.amazonaws.com/docs/indiaai-21-women-in-21.pdf (Accessed 30 August 2022.)

Intel and ISB. 2020. *The Impact of AI on the Indian Labour Market*. https://newsroom.intel.com/wp-content/uploads/sites/11/2020/10/The-Impact-of-AI-on-the-Indian-Labour-Market.pdf (Accessed 30 August 2022.)

International Baccalaureate Diploma Programme. 2022. *Theory of Knowledge Guide*. https://erhs.la/sites/default/files/global/theory_of_knowledge_guide_2022.pdf (Accessed 30 August 2022.)

International Labour Organization. 2020. *The Feasibility of using Big Data in Anticipating and Matching Skills Needs*. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_759330.pdf (Accessed 30 August 2022.)

Jeevithashree, D. V., Saluja, K. P. S. and Biswas P. 2019. A case study of developing gaze-controlled interface for users with severe speech and motor impairment. *Technology and Disability*, Vol. 31, No. 1, IOS Press.

Jeevithashree, D. V., Jain, P., Mukhopadhyay, A., Saluja, K. P. S. and Biswas, P. 2021. Eye gaze controlled adaptive virtual keyboard for users with SSMI. *Technology and Disability*, Vol. 33, No. 4, IOS Press.

Kasinathan, G. 2020. Making AI work in Indian education. *Artificial Intelligence in India*, Vol. 6. http://library.fes.de/pdf-files/bueros/indien/15953.pdf (Accessed 30 August 2022.)

Korinek, A. and Stiglitz, J. E. 2018. Artificial intelligence and its implications for income distribution and unemployment. A. Agrawal, J. Gans and A. Goldfarb (eds), *The Economics of Artificial Intelligence: An Agenda*. London, The University of Chicago Press, pp. 349-90. https://www.nber.org/system/files/chapters/c14018/c14018.pdf (Accessed 30 August 2022.)

Kuprenko, V. 2020. Artificial Intelligence in Education: benefits, challenges, and use cases. *Towards AI*. https://pub.towardsai.net/artificial-intelligence-in-education-benefits-challenges-and-use-cases-db52d8921f7a (Accessed 3 May 2022.)

Lane, H. C. and VanLehn, K. 2004. A dialogue-based tutoring system for beginning programming. *Proceedings of the Seventeenth International Florida Artificial Intelligence Research Society Conference (FLAIRS)*, Vol. 2, pp. 449-54.

Laney, D. 2001. *3D Data Management: Controlling Data Volume, Velocity and Variety*. Application Delivery Strategies. META Group Inc. https://studylib.net/doc/8647594 (Accessed 30 August 2022.)

Lee, K. F. and Chen, Q. 2021. *AI 2041: Ten Visions for Our Future*. New York, Currency.

Legg, S. and Hutter, M. 2007. Universal intelligence: a definition of machine intelligence. *Minds and Machines*, Vol. 17, No. 4, pp. 391-444. https://arxiv.org/pdf/0712.3329.pdf (Accessed 31 August 2022.)

Lohn, A. J. 2021. *Poison in the Well: Securing the Shared Resources of Machine Learning*. CSET Policy Brief. https://cset.georgetown.edu/wp-content/uploads/CSET-Poison-in-the-Well.pdf (Accessed 30 August 2022.)

Long, D. and Magerko, B. 2020. What is AI literacy? Competencies and design considerations. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, pp. 1-16. https://aiunplugged.lmc.gatech.edu/wp-content/uploads/sites/36/2020/08/CHI-2020-AI-Literacy-Paper-Camera-Ready.pdf (Accessed 31 August 2022.)

Opposite page: Mixed reality-based robot control. Indian Institute of Science, Bengaluru, Karnataka, India.

Luckin, R., Holmes, W., Griffiths, M. and Forcier, L. B. 2016. *Intelligence Unleashed: An Argument for AI in Education*. London, Pearson Education. http://oro.open.ac.uk/50104/1/Luckin%20et%20al.%20-%202016%20-%20Intelligence%20Unleashed.%20An%20argument%20for%20AI%20in%20Educ.pdf (Accessed 30 August 2022.)

Machado, M. d. O. C., Bravo, N. F. S., Martins, A. F., Bernardino, H. S., Barrere, E. and de Souza, J. F. 2021. Metaheuristic-based adaptive curriculum sequencing approaches: a systematic review and mapping of the literature. *Artificial Intelligence Review*, Vol. 54, No. 1, pp. 711-54. https://www.researchgate.net/profile/Marcelo-Machado-6/publication/342502222_Metaheuristic-based_adaptive_curriculum_sequencing_approaches_a_systematic_review_and_mapping_of_the_literature/links/5fab8fa492851cf7dd0ddf8f/Metaheuristic-based-adaptive-curriculum-sequencing-approaches-a-systematic-review-and-mapping-of-the-literature.pdf (Accessed 30 August 2022.)

Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., Ko, R. and Sanghvi, S. 2017. *Jobs Lost, Jobs Gained: Workforce Transitions in a time of Automation*. McKinsey Global Institute. https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages# (Accessed 30 August 2022.)

Marshall, R., Pardo, A., Smith, D. and Watson, T. 2022. Implementing next generation privacy and ethics research in education technology. *British Journal of Educational Technology.*

McCarthy, J., Minsky, M. L., Rochester, N. and Shannon, C. E. 1955. *A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence*. http://www-formal.stanford.edu/jmc/history/dartmouth/dartmouth.html (Accessed 30 August 2022.)

Mezzanzanica, M. and Mercorio, F. 2019. *Big Data for Labour Market Intelligence: An Introductory Guide*. European Training Foundation. https://www.etf.europa.eu/sites/default/files/2019-06/Big%20data%20for%20LMI.pdf (Accessed 30 August 2022.)

Ministry of Education (Government of India). 2020a. *National Education Policy 2020*. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf (Accessed 30 August 2022.)

Ministry of Education (Government of India). 2020b. *All India survey on higher education 2019-20*. https://www.education.gov.in/sites/upload_files/mhrd/files/statistics-new/aishe_eng.pdf (Accessed 30 August 2022.)

Ministry of Education (Government of India). 2021a. *National Digital Education Architecture*. https://www.ndear.gov.in/policies-and-standards.html (Accessed 31 August 2022.)

Ministry of Education (Government of India). 2021b. *Unified District Information System for Education Plus (UDISE+)*. https://dashboard.udiseplus.gov.in/assets/images/pdf/UDISE+2019_20_Booklet.pdf (Accessed 30 August 2022.)

Ministry of Health and Family Welfare (Government of India). 2021. *National Family Health Survey 2019-21*. http://rchiips.org/nfhs/NFHS-5_FCTS/Final%20Compendium%20of%20fact%20sheets_India%20and%2014%20States_UTs%20(Phase-II).pdf (Accessed 30 August 2022.)

Molenaar, I. 2021. Personalisation of learning: towards hybrid human-AI learning technologies. *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*. Paris, OECD Publishing. https://www.oecd-ilibrary.org/sites/2cc25e37-en/index.html?itemId=/content/component/2cc25e37-en (Accessed 30 August 2022.)

Muralidharan, K., Singh, A. and Ganimian, A. J. 2019. Disrupting education? Experimental evidence on technology-aided instruction in India. *American Economic Review*, Vol. 109, No. 4, pp. 1426-60.

Murphy, R. F. 2019. *Artificial Intelligence Applications to Support K–12 Teachers and Teaching: A Review of Promising Applications, Challenges, and Risks*. Santa Monica (CA), RAND Corporation. https://www.rand.org/content/dam/rand/pubs/perspectives/PE300/PE315/RAND_PE315.pdf (Accessed 30 August 2022.)

Murthy, L. R. D. and Biswas, P. 2021. Appearance-based gaze estimation using attention and difference mechanism. *3rd International Workshop on Gaze Estimation and Prediction in the Wild (GAZE 2021) at CVPR.*

NASSCOM. 2020. *Unlocking Value from Data and AI - The India Opportunity*. https://nasscom.in/knowledge-center/publications/unlocking-value-data-and-ai-india-opportunity (Accessed 30 August 2022.)

NCE. 2020. *Spotlight Report on Status of SDG 4 in India 2020*. http://nceindia.org.in/wp-content/uploads/2021/09/Spotlight-Report-2020.pdf (Accessed 30 August 2022.)

NITI Aayog. 2018. *Discussion Paper: National Strategy for Artificial Intelligence*. https://indiaai.gov.in/documents/pdf/NationalStrategy-for-AI-Discussion-Paper.pdf (Accessed 30 August 2022.)
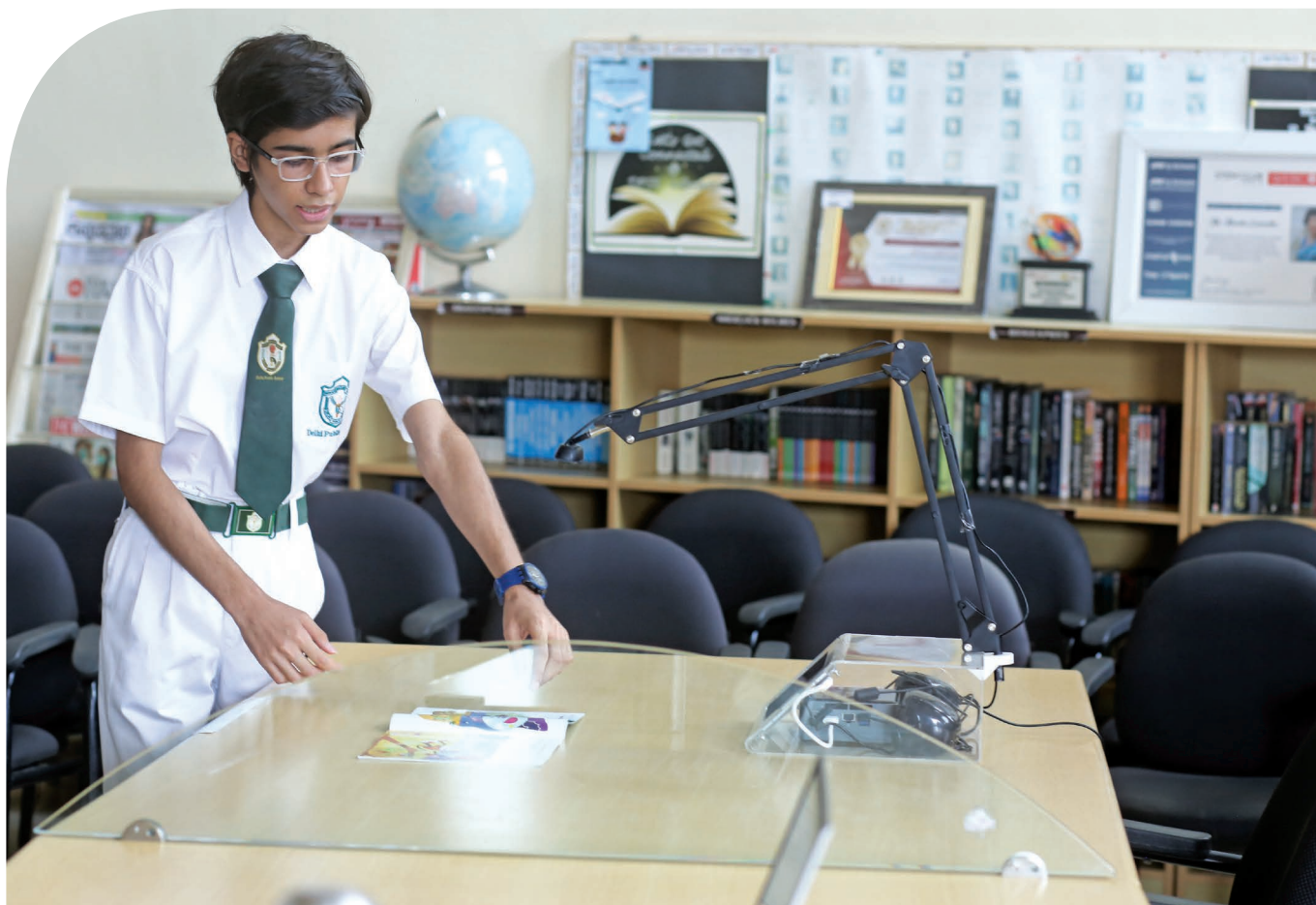
Above: A school student has developed an AI reading assistant using computer vision technology and natural language processing. Delhi Public School Bangalore East, Bengaluru, Karnataka, India.

NITI Aayog. 2021a. *Responsible AI. Approach Document for India. Part 1 – Principles for Responsible AI.* https://www.niti.gov.in/sites/default/files/2021-02/Responsible-AI-22022021.pdf (Accessed 30 August 2022.)

NITI Aayog. 2021b. *Responsible AI. Approach Document for India. Part 2 - Operationalizing Principles for Responsible AI.* https://www.niti.gov.in/sites/default/files/2021-08/Part2-Responsible-AI-12082021.pdf (Accessed 30 August 2022.)

NITI Aayog. 2021c. *The Atal Tinkering Lab handbook 2.0.* https://aim.gov.in/pdf/ATL_Handbook_2021.pdf (Accessed 30 August 2022.)

Noorbehbahani, F., Mohammadi, A. and Aminazadeh, M. 2022. A systematic review of research on cheating in online exams from 2010 to 2021. *Education and Information Technologies,* Vol. 27, pp. 8413–8460. https://link.springer.com/article/10.1007/s10639-022-10927-7 (Accessed 30 August 2022.)

Nottingham, E., Stockman, C. and Burke, M. 2022. Education in a datafied world: balancing children's rights and school's responsibilities in the age of Covid 19. *Computer Law & Security Review,* Vol. 45, p. 105664.

OECD. 2021. *Gender Equality Initiative: Key Charts on Employment.* https://www.oecd.org/gender/data/employment/ (Accessed 26 May 2022.)

OECD. 2022. Time-Use Statistics. https://stats.oecd.org/Index.aspx?datasetcode=TIME_USE (Accessed 26 May 2022.)

OECD.AI. (2022). *Domestic and International Collaboration in AI Software Development.* https://oecd.ai/en/data?selectedArea=ai-software-development&selectedVisualization=domestic-and-international-collaboration-in-ai-software-development (Accessed 2 June 2022.)

Ouyang, F. and Jiao, P. 2021. Artificial intelligence in education: the three paradigms. *Computers and Education: Artificial Intelligence,* Vol. 2, p. 100020.

Perelman, L. 2020. The BABEL generator and E-rater: 21st century writing constructs and automated essay scoring (AES). *Journal of Writing Assessment,* Vol. 13, No. 1. https://escholarship.org/content/qt263565cq/qt263565cq.pdf (Accessed 30 August 2022.)

Pinkwart, N. 2016. Another 25 years of AIED? Challenges and opportunities for intelligent educational technologies of the future. *International Journal of Artificial Intelligence in*

Education, Vol. 26, No. 2, pp. 771-83. https://link.springer.com/article/10.1007/s40593-016-0099-7 (Accessed 30 August 2022.)

Porayska-Pomsta, K. and Holmes, W. 2023. Toward ethical AIED. In W. Holmes and K. Porayska-Pomsta (eds.), *The Ethics of AI in Education. Practices, Challenges, and Debates*. New York, Routledge, pp. 271–81.

Raj, A., Salazar, M., Jackson, E. C., Wyss, N., McClendon, K. A., Khanna, A., Belayneh, Y. and McDougal, L. 2019. Students and brides: a qualitative analysis of the relationship between girls' education and early marriage in Ethiopia and India. *BMC Public Health*, Vol. 19, No. 1, pp. 1-20.

Ramanaik, S., Collumbien, M., Prakash, R., Howard-Merrill, L., Thalinja, R., Javalkar, P., Murthy, S., Cislaghi, B., Beattie, T., Isac, S. and Moses, S. 2018. Education, poverty and 'purity' in the context of adolescent girls' secondary school retention and dropout: a qualitative study from Karnataka, southern India. *PLoS One*, Vol. 13, No. 9, p.e0202470.

Rawal, S. and Kingdon, G. 2010. Akin to my teacher: does caste, religious or gender distance between student and teacher matter? Some evidence from India. *DoQSS Working Papers 10-18*. Quantitative Social Science – UCL Social Research Institute, University College London. https://ideas.repec.org/p/qss/dqsswp/1018.html (Accessed 30 August 2022.)

Reddy K. P. N., Alekhya, T., Sushma Manjula, T. and Krishnappa, R. 2019. AI-based attendance monitoring system. *International Journal of Innovative Technology and Exploring Engineering*, Vol. 9, pp. 592-97.

Ribeiro, B., Gonçalves, I., Santos, S. and Kovacec, A., 2011. Deep learning networks for off-line handwritten signature recognition. *Iberoamerican Congress on Pattern Recognition*. Springer, Berlin, Heidelberg, pp. 523-32. https://link.springer.com/content/pdf/10.1007/978-3-642-25085-9_62.pdf (Accessed 30 August 2022.)

Rogerson, A. M. and McCarthy, G. 2017. Using Internet based paraphrasing tools: original work, patchwriting or facilitated plagiarism? *International Journal for Educational Integrity*, Vol. 13, No. 1, pp. 1-15. https://edintegrity.biomedcentral.com/articles/10.1007/s40979-016-0013-y?preview=true&site_id=756 (Accessed 30 August 2022.)

Rowntree, O. 2019. *The Mobile Gender Gap Report 2019*. GSM Association. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2019/03/GSMA-Connected-Women-The-Mobile-Gender-Gap-Report-2019.pdf (Accessed 30 August 2022.)

Russell, S. J. and Norvig, P. 2020. *Artificial Intelligence: A Modern Approach*, 4th edn.

Hoboken (NJ), Pearson Education Inc.

Saheb, T., Saheb, T. and Carpenter, D.O. 2021. Mapping research strands of ethics of artificial intelligence in healthcare: a bibliometric and content analysis. *Computers in Biology and Medicine*, Vol. 135. https://www.sciencedirect.com/science/article/abs/pii/S0010482521004546 (Accessed 30 August 2022.)

Sanna, A., Lamberti, F., Paravati, G. and Demartini, C. 2012. Automatic assessment of 3D modeling exams. *IEEE Transactions on Learning Technologies*, Vol. 5, No. 1, pp. 2-10.

Sambasivan, N., Arnesen, E., Hutchinson, B., Doshi, T. and Prabhakaran, V. 2021. Re-Imagining algorithmic fairness in India and beyond. *Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency*, pp. 315-28. https://dl.acm.org/doi/pdf/10.1145/3442188.3445896 (Accessed 30 August 2022.)

Sattva. 2020. *Read Along Impact Assessment Study Report*. https://www.sattva.co.in/wp-content/uploads/2020/09/Sattva_Google_Read-Along-IA-Report.pdf (Accessed 30 August 2022.)

Sharma, V. K., Murthy L. R. D. and Biswas, P. 2022. Comparing two safe distance maintenance algorithms for a gaze controlled HRI involving users with SSMI. *ACM Transactions on Accessible Computing*, Vol. 15, No. 3.

Sivakami, M., van Eijk, A. M., Thakur, H., Kakade, N., Patil, C., Shinde, S., Surani, N., Bauman, A., Zulaika, G., Kabir, Y. and Dobhal, A. 2019. Effect of menstruation on girls and their schooling, and facilitators of menstrual hygiene management in schools: surveys in government schools in three states in India, 2015. *Journal of Global Health*, Vol. 9, No. 1.

Stapleton, K., Copestake, A. and Pople, A. 2021. *AI, firms and wages: Evidence from India*. https://copestake.info/workingpaper/akai/AKAI.pdf (Accessed 30 August 2022.)

Strubell, E., Ganesh, A. and McCallum, A. 2019. *Energy and Policy Considerations for Deep Learning in NLP*. https://arxiv.org/pdf/1906.02243.pdf (Accessed 30 August 2022.)

Turing, A. M. 1950. Computing machinery and intelligence. *Mind*, Vol. 59, No. 236, pp. 433-60. https://phil415.pbworks.com/f/TuringComputing.pdf (Accessed 31 August 2022.)

UNESCO and International Research Centre in Artificial Intelligence. To be published. *Open data for the UN Sustainable Development Goals*.

UNESCO, OECD and IDB (2022). *The Effects of AI on the Working Lives of Women*. Paris and New York, UNESCO, OECD, IDB. https://unesdoc.unesco.org/ark:/48223/pf0000380861 (Accessed 30 August 2022.)

UNESCO. 2003. *Gender Equality in Education in India.* https://unesdoc.unesco.org/ark:/48223/pf0000146911 (Accessed 30 August 2022.)

UNESCO. 2019a. *International Conference on Artificial Intelligence and Education, Planning Education in the AI Era: Lead the Leap.* Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000370967 (Accessed 30 August 2022.)

UNESCO. 2019b. *Steering AI and Advanced ICTs for Knowledge Societies: A Rights, Openness, Access, and Multi-stakeholder Perspective.* Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000372132 (Accessed 30 August 2022.)

UNESCO. 2019c. *Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development.* Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000366994 (Accessed 30 August 2022.)

UNESCO. 2020. *AI in Education: Change at the Speed of Learning.* UNESCO Institute for Information Technologies in Education Policy Brief. Moscow, UNESCO IITE. https://iite.unesco.org/publications/ai-in-education-change-at-the-speed-of-learning/#:~:text=Artificial%20Intelligence%20(AI)%20will%20play,needs%20of%20each%20individual%20student (Accessed 30 August 2022.)

UNESCO. 2021a. *State of the Education Report for India: No teacher, no class.* New Delhi, UNESCO Cluster Office. https://unesdoc.unesco.org/ark:/48223/pf0000379115 (Accessed 30 August 2022.)

UNESCO. 2021b. *Recommendation on the Ethics of Artificial Intelligence.* Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000381137 (Accessed 30 August 2022.)

UNESCO. 2021c. *World Teachers' Day 2021 Fact Sheet.* Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000379187 (Accessed 30 August 2022.)

UNESCO. 2021d. *International Forum on AI and the Futures of Education, Developing Competencies for the AI Era: Synthesis Report.* Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000377251 (Accessed 30 August 2022.)

UNESCO. 2021e. *AI and Education Guidance for Policy-makers.* Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000376709 (Accessed 30 August 2022.)

UNESCO. 2022. *K-12 AI Curricula: A Mapping of Government-Endorsed AI Curricula.* Paris, UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000380602 (Accessed 30 August 2022.)

UNICEF and UNESCO. 2021. *India Case Study: Situation Analysis on the Effects of and Responses to COVID-19 on the Education Sector in Asia.* https://www.unicef.org/rosa/media/16511/file/India%20Case%20Study.pdf (Accessed 30 August 2022.)

UNICEF. 2017. *The State of the World's Children 2017: Children in a Digital World.* New York, UNICEF Division of Communication. https://www.unicef.org/media/48601/file (Accessed 30 August 2022.)

Vashisht, A., Pathak, R., Agarwalla, R., Patavegar, B. N. and Panda, M. 2018. School absenteeism during menstruation amongst adolescent girls in Delhi, India. *Journal of family & community medicine*, Vol. 25, No. 3, pp. 163-68.

Vincent-Lancrin, S. 2020. *Coronavirus and the Future of Learning: What AI could have made Possible.* OECD Education and Skills Today. https://oecdedutoday.com/coronavirus-future-learning-artificial-intelligence-ai/ (Accessed 26 May 2022.)

Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Felländer, A., Langhans, S.D., Tegmark, M. and Fuso Nerini, F. 2020. The role of artificial intelligence in achieving the Sustainable Development Goals. *Nature Communications*, Vol. 11, No. 1, pp. 1-10. https://www.nature.com/articles/s41467-019-14108-y.pdf (Accessed 30 August 2022.)

Wang, Y. 2021. Artificial intelligence in educational leadership: a symbiotic role of human-artificial intelligence decision-making. *Journal of Educational Administration*, Vol. 59, No. 3, pp. 256-270. https://doi.org/10.1108/JEA-10-2020-0216

World Economic Forum. 2018. *The Global Gender Gap Report 2018.* Cologne/Geneva, World Economic Forum. https://www3.weforum.org/docs/WEF_GGGR_2018.pdf (Accessed 30 August 2022.)

World Economic Forum. 2021. *The Global Gender Gap Report 2021.* Cologne/Geneva, World Economic Forum. https://www3.weforum.org/docs/WEF_GGGR_2021.pdf (Accessed 30 August 2022.)

Worsley, M., Barel, D., Davison, L., Large, T. and Mwiti, T. 2018. Multimodal interfaces for inclusive learning. *19th International Conference on Artificial Intelligence in Education (AIED 2018).* London, Springer, pp. 389-93.

Yampolskiy, R. V. 2020. Unexplainability and incomprehensibility of AI. *Journal of Artificial Intelligence and Consciousness*, Vol. 7, No. 2, pp. 277-91. https://arxiv.org/ftp/arxiv/papers/1907/1907.03869.pdf (Accessed 31 August 2022.)

Yampolskiy, R. V. and Govindaraju, V. 2008. Behavioural biometrics: a survey and classification. *International Journal of Biometrics*, Vol. 1, No. 1, pp. 81-113. https://cubs.buffalo.edu/images/pdf/pub/Behavioral-Biometrics-A-Survey-and-Classification.pdf (Accessed 30 August 2022.)

Yang, S. J., Ogata, H., Matsui, T. and Chen, N. S. 2021. Human-centered artificial intelligence in education: seeing the invisible through the visible. *Computers and Education: Artificial Intelligence*, Vol. 2, p. 100008.

Zhang, D., Maslej, N., Brynjolfsson, E., Etchemendy, J., Lyons, T., Manyika, J., Ngo, H., Niebles, J. C., Sellitto, M., Sakhaee, E., Shoham, Y., Clark, J. and Perrault, R. 2022. *Artificial Intelligence Index Report 2022*. Stanford (CA), AI Index Steering Committee, Human-Centered AI Institute, Stanford University. https://aiindex.stanford.edu/wp-content/uploads/2022/03/2022-AI-Index-Report_Master.pdf (Accessed 30 August 2022.)

Zhang, D., Mishra, S., Brynjolfsson, E., Etchemendy, J., Ganguli, D., Grosz, B., Lyons, T., Manyika, J., Niebles, J. C., Sellitto, M., Shoham, Y., Clark, J. and Perrault, J. 2021. *Artificial Intelligence Index Report 2021*. Stanford (CA), AI Index Steering Committee, Human-Centered AI Institute, Stanford University. https://aiindex.stanford.edu/wp-content/uploads/2021/11/2021-AI-Index-Report_Master.pdf (Accessed 30 August 2022.)

Ziesche, S. 2017. *Innovative Big Data Approaches for Capturing and Analyzing Data to Monitor and Achieve the SDGs.* Report of the United Nations Economic and Social Commission for Asia and the Pacific: Subregional Office for East and North-East Asia (ESCAP-ENEA). https://www.unescap.org/sites/default/files/publications/Innovative%20Big%20Data%20Approaches%20for%20Capturing%20and%20Analyzing%20Data%20to%20Monitor%20and%20Achieve%20the%20SDGs.pdf (Accessed 30 August 2022.)

Below: Assembling parts is a crucial aspect of developing AI products. Amrita Vishwa Vidyapeetham, Kerala, India.
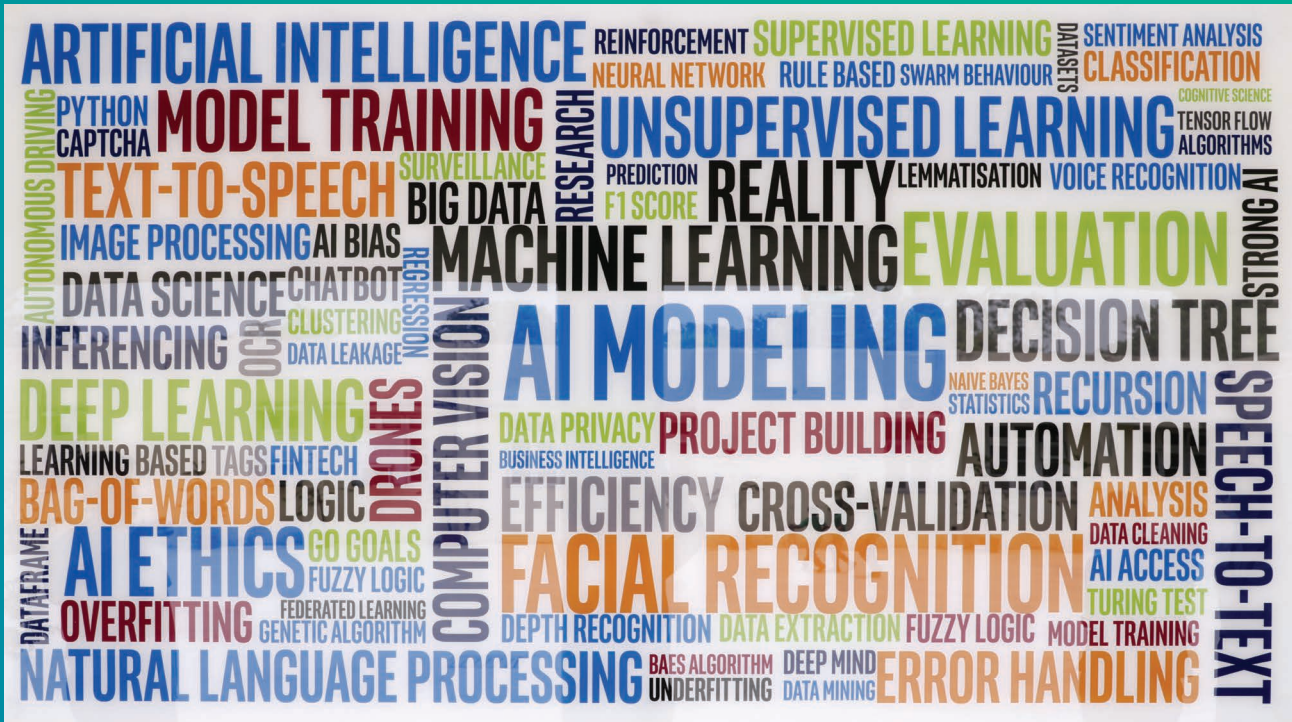
Vantage is an international multi-asset broker headquartered in Sydney, Australia, with over twelve years of market experience. As a global company, Vantage is committed to its environmental, social, and governance (ESG) principles, supporting communities around the world and protecting the planet in its operations, so that everyone can be better off than they were before.

Vantage's partnership with UNESCO was sparked by common long-term goals for sustainable development and a better shared future through the equitable distribution of resources and greater access to quality education. It is also an affirmation of Vantage's commitment to the highest standards of equity, fairness, accountability and excellence.

Vantage's corporate ESG initiative was formalized in July 2022, driven by a collective desire among its staff to make the world a better place, while providing an avenue for resources and ideas to be shared across borders for greater impact. Its previous ESG initiatives include a fundraising activity with UNHCR; a partnership with a popular digital media publisher called Supercar Blondie to highlight the Blue Carbon ESG initiative in Sardinia, Italy; and a multi-year sponsorship of the McLaren MX Extreme E team in support of sustainability and innovation, gender equality and positive climate action.