AI & Education: An Opportunity for Growth

The COVID-19 pandemic offers the chance to reflect on the opportunities and challenges of using AI and digital technologies for education and learning.[1] During the COVID-19 pandemic classrooms in many countries have closed and children are at risk of failing to keep up with lessons. Conferences[2] and organizations are suggesting opportunities for home learning and offering free textbooks and online courses. However, while there is an opportunity for technology to amplify student learning at home, differences in access to technology forewarn of a widening gap in inequality and inclusion. Children with less access to learning opportunities at home face the risk of falling farther behind.

This briefing memo explores 'AI for education' and 'education for AI'. It first outlines the primary opportunities and challenges of AI for education. Then, it presents the latest recommendations in education policy to prepare students for the future of work in the digital and AI economy. Policymakers and education experts globally can use this briefing memo as background for more tailored approaches that vary by country and context.

The Future Society is a global nonprofit think-and-do-tank with the mission to advance the responsible adoption of AI for the benefit of humanity. Through policy research, advisory, and education courses, we help decision-makers harness the opportunities presented by AI while mitigating their risks. To learn more about AI for education and prepare for the future of work, please reach out to Yolanda Lannquist at Yolanda.Lannquist@thefuturesociety.org.

Thank you,
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[1] For a complete list of opportunities and challenges of COVID-19 on education refer to Petrie, C., Aladin, K., Ranjan, P., Javangwe, R., Gilliland, D., Tuominen, S. and L. Lasse. 2020. Spotlight: Quality education for all during Covid-19 crisis. HundrED and OECD. Hundred.org/en/research.
[2] https://www.cmrubinworld.com/how-to-expand-high-quality-learning-access-for-all-students/

Opportunities & Challenges of AI for Education

Countries have the potential to harness AI to address pressing needs including increasing access to quality education. Education can close societal divides including the gender gaps in digital skills and jobs. The third annual *AI for Good Global Summit* in Geneva organized by ITU and UN agencies explored numerous use cases and opportunities to use AI for education. There, The Future Society spearheaded the synthesis of these opportunities and risks.[3]

There are numerous ways that use of AI in the classroom can improve learning and increase efficiencies by reducing teacher workload.[4] Other AI tools include the following:

- Personalized, hyper-tailored, self-paced individual learning
- Adaptive learning to recommend lesson content
- Virtual & augmented reality for immersive training (e.g. cadavers for medical students)
- Intelligent Tutoring Systems and personalized tutors[5]
- Virtual personal assistants
- Robo-readers and robo-graders
- Simulations for “trial and error” tools
- Empathetic AI to detect student distress early

AI will help move EdTech in the direction of self-paced, individual learning, with hyper-tailored tutoring (through virtual personal assistants), which will eventually bring personalization of teaching at scale. The example of the Cognitive Tutor[6] developed at Carnegie Mellon University is a pertinent example of how AI can help shape and deliver optimal teaching strategies for individual students, thanks to learning analytics and intelligent feedback to identify and monitor weaknesses, which then informs curricula adaptation.

Machine learning algorithms are now used to move plagiarism investigations across several languages, to include non-digitized sources, and to make it much smarter than brute force methods. “Robo-readers” or “robo-graders” exhibit a lot of potential for scoring and providing feedback on essay grading, although progress is still needed to reach a sophisticated level of semantic processing. Expected advances in natural language processing in the coming decades should be instrumental. Simulations and gamification have the potential to better engage students through fun “trial and error” tools. Learning environments such as Virtual

[3] https://thefuturesociety.org/events/ai-for-good-global-summit-2019/
[4] See Annex 1: Potential impact that AI can bring to middle school teachers’ job tasks
[5] For example ‘Amy: Making maths easy for everyone’ personalized tutor in New Zealand.
[6] http://ctat.pact.cs.cmu.edu/

Reality will allow immersive, high-resolution, hyper-realistic training, and are poised to profoundly affect teaching methods (see the fold-it[7] and mozak[8] human-based computation games, for instance). As *Wired* Magazine creator Kevin Kelly summarized in his 2016 book *The Inevitable*:83 "*if AI can help humans become better chess players, it stands to reason that it can help us become better pilots, better doctors, better judges, better teachers*."[9]

While education is a sector largely ripe for disruption by AI, barriers of entry are still high, cycles longer and slower, and conservatism more entrenched. As a result, no large actor has yet brought upon a transformational offer. If mass education's intrinsically governmental nature is a great asset to foster diffusion of scaled innovations to all, it is also a liability due to excessive rigidity in most countries. Public-private partnerships offer an interesting path to capture the revolution in education.

However, in a 'more to gain, more to lose' paradigm, AI and digital technologies bring important risks to be carefully managed. A top issue is how to expand access to AI and digital technologies broadly for education. In a context of large digital divides within and across countries, differences in access can widen existing inequalities and threaten to leave some students even farther behind. In this case, AI can widen the gap between under-connected and digitally connected peoples and countries, making integration into the digital and AI economy more difficult. The report 'A Framework guide to an education response to the COVID-19 pandemic of 2020' presents statistics and differences among countries regarding school practices using digital devices and access to online learning platforms.[10]

Specifically, the use of AI and digital technologies in the classroom raises new concerns. There is a need to monitor impacts and unintended consequences on children. For example, monitoring systems used in classrooms to evaluate students' level of attention can have adverse effects. Human-like ('anthropomorphic') smart toys can confuse children's relationship with others. In a similar way, female voices in AI assistants can reinforce biases about female obedience. More generally, AI technologies bring a suite of risks to manage including users' privacy and data protection.

Increasingly aware of strategic economic, social, and political issues at stake, governments worldwide have released a series of national strategies and policy approaches aimed to

[7] http://fold.it/portal/
[8] http://www.mozak.science/landing
[9] Kelly, K. 2016. The Inevitable: Understanding the 12 Technological Forces That Will Shape Our Future.
[10] A Framework guide to an education response to the COVID-19 pandemic of 2020. Reimers, F. M. and A. Schleicher. 2020. A Framework guide to an education response to the COVID-19 pandemic of 2020. Global Education Innovation Initiative, Harvard Graduate School of Education and Directorate of Education and Skills, OECD.

accelerate AI adoption.[11] A host of national AI strategies now explicitly include use of AI for education.

Figure 1 - National AI strategies including use of AI for education

Source: The Future Society. Last updated in 2019. Note: Due to rapid growth in the number of AI strategies table may exclude new national AI strategies such as by Qatar, Brazil, Austria, and more.

[11] The Future Society and World Bank. Policy Pathways for Harnessing AI for Development. https://thefuturesociety.org/2019/08/15/governing-the-ai-adoption-in-developing-countries/

Education for AI: 21st Century Education & Skills Development

"The things we teach our kids are from the past 200 years, it is knowledge-based. We cannot teach our kids to compete with machines." - Jack Ma, Alibaba

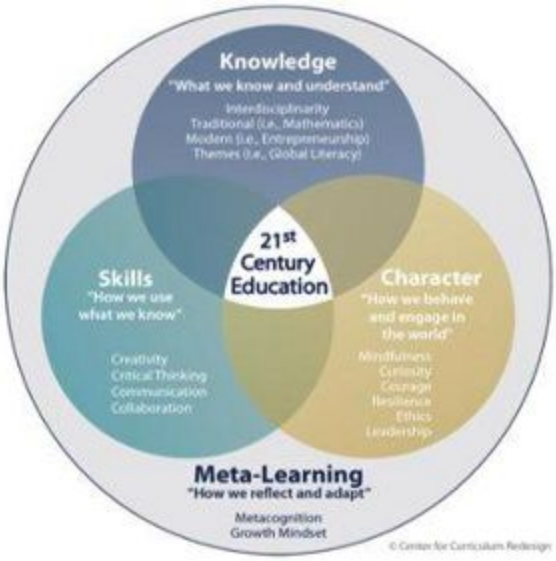
With the rapid transformation of our workforce and the economy in the age of AI, education models must be updated to prepare citizens to compete for jobs and thrive alongside increasing machine capabilities. Education policy is critical to ensuring that access and the economic gains from AI are more widely distributed, and to boost inclusion and reduce the widening digital divide and the inequality which may ensue alongside automation of jobs.

Many public education systems were established to transition citizens from unskilled and agricultural workers to participate in the industrial revolution. With the Fourth Industrial Revolution, reforms to curricula in both content and pedagogical approaches are needed. Because of longer time horizons for measurable impact of education reform, it is important to begin the re-designing process immediately and prepare society for the impact of AI.

New Skills for the Age of AI

A wide range of new skills and competencies are needed to prepare citizens to compete for jobs and to contribute to society in the digital age, including global literacy, digital literacy, critical thinking, creativity, collaboration, communication, 'adaptability' and 'learning to learn'.

Therefore, emphasis should broaden from knowledge to skill acquisition, character-building, and meta-learning. The Centre for Curriculum Redesign (CCR) identifies these four aspects in their 'four-dimensional educational framework' as essential components with which students should be equipped to thrive in the future. Knowledge should include interdisciplinary coursework and build on 'traditional' subjects, such as math & science, while enlarging it with modern disciplines, such as entrepreneurship, wellness or financial literacy. Skill-building should include creativity, critical thinking, communication and collaboration. Character is an important dimension as it sets "how we behave and engage in the world," encompassing mindfulness, curiosity, courage, resilience, ethics and leadership. Especially coursework in ethics is crucial as society begins to lay new standards and norms for the new ethical challenges posed by AI.



Source: Center for Curriculum Redesign

Labour market demands

Organizations may re-organize work among machines and humans to benefit from the advantages of each. Employers can defer routine or calculative tasks to machines while humans take on roles requiring strong skills in interpersonal relations, judgement, teamwork and management. According to the World Economic Forum, the top skills in demand by employers in 2020 will be 1) Complex Problem Solving, 2) Critical Thinking, 3) Creativity, 4) People Management, 5) Coordinating with Others, 6) Emotional Intelligence, 7) Judgment and Decision Making, 8) Service Orientation, 9) Negotiation, and 10) Cognitive Flexibility.[12]

Technical & digital skills

Meanwhile, it is increasingly important for citizens to be equipped with 'digital literacy' to understand how to participate in the digital economy. Digital literacy involves not only skills to gain employment in the digital economy but also to equip citizens to mitigate new risks and challenges, such as 'fake news,' deceptive videos and content, and cybersecurity risks. Public education campaigns to raise awareness about AI technologies can help equip citizens to understand the capabilities, limitations and manage risks of AI and other emerging technologies.

[12] World Economic Forum. 2018. *Future of Jobs Report*.

There will be need for data scientists, software engineers, and machine learning professionals to develop, manage and audit AI systems and other digital technologies. As AI and big data take on more prevalent roles, and delegation of decision-making and agency shifts from humans to machines, there will be growing importance for humans equipped with technical capabilities. For individuals, firms, and countries to compete in the global talent market or the global economy, education systems must also work to improve STEM (science, technology, engineering and mathematics) education.

Technical education in machine learning and AI are valuable to prepare citizens for employment in the future. National AI strategies are increasingly focusing on domestic talent development in AI, whether to extract strategic value from global economic, political or military competition or to take advantage of opportunities to leverage AI for economic and productivity.[13]

Because of the central role of data in machine learning, boundaries between fundamental research, applied research, engineering and higher education are likely to blur. We already see a trend of fundamental research in AI shifting away from universities and government laboratories to the biggest technology companies. Academics worry about what they call a "brain drain" which could damage the quality of public research and education down-the-line.[14]

'Adaptability,' 'flexibility and 'learnability'

With rapid technological development and increasingly globalized and interconnected markets, the skills demanded by employers will be subject to constant change and updating. It will become increasingly important for adults, including mid-career professionals, to be flexible and adaptable to changing work environments and skill needs. As identified in the CCR framework, fourth dimension of 'meta-learning', or 'learning to learn' multiple times throughout one's lifetime, will become a critical capability that can distinguish individuals who compete in labor markets or those who face automation. Willingness, rather than fatigue, to learn new skills will become important.

[13] Dutton, T. 2018. *Overview of National AI Strategies.* AI + Politics, Medium.

[14] Waters, R. 2016. *AI academic warns on brain drain to tech groups*. Financial Times. https://www.ft.com/content/298e2ac0-b010-11e6-a37c-f4a01f1b0fa1

New models for education

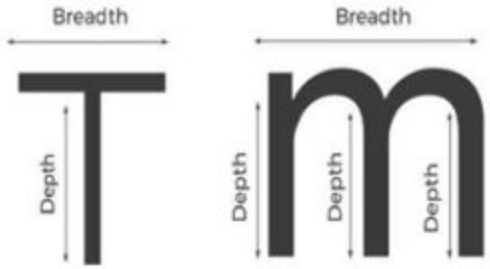
New models of education and training delivery can support building the skills and competencies for work and participation in the digital age. Present returns to education are low, and more focus is needed at the mid-career levels. To deliver education for new skills and competencies, and lifelong learning, retraining and upskilling, new models for education delivery will be needed.

> *"We should imagine new institutions and mechanisms to teach the skills and competencies to meet employment needs. Disruption will come from the outside, from new models.*" - Contributor, The Future Society's Global Civic Debate, 'Governing the Rise of AI'

Continuous & lifelong education

Learning and education will need to be delivered throughout working age until retirement. The distinction between an education period during youth and a working period during adulthood, where individuals apply this education, will blur. As technology changes, adults will need continuous and ongoing retraining and upskilling to keep up with changing workforce demands.

Jim Spohrer, a computer scientist at IBM, has explained "M-shaped" learners as those who develop depth in several subjects over their lifetime. Compared to T-shaped individual who build breadth across subjects and depth in one or few, the M-shaped individual will be more robust to changing workforce and societal trends.



Source: T-Shaped individual: Jim Spohrer, IBM; M-Shaped: the Centre for Curriculum Redesign

Technology for education

Technology offers new models for education and training. MOOCs, or massive open online courses, offer education to new populations, despite criticism that MOOCs serve select groups that are already tech-savvy and self-motivated.

AI can support education and training in new ways. Personalized and hyper-tailored learning enabled by machine learning can adapt to students' unique learning styles and interests. Virtual reality simulations can help to visualize lessons (as an example, consider exploring the pyramids to study geometry). AI can also support teachers with auto-grading and assistant tools.

Virtual (VR) and augmented reality (AR) offer new tools for immersive training. In industrial and military sectors, simulations can providing training opportunities for rare or dangerous scenarios. VR and AR can provide opportunities for learning and training with scarce resources, for example cadavres for medical students. They are also tools for educating those often left out, like the elderly or differently-abled children. Simulations for emergency situations can prepare professionals for emergency reflexive responses.[15]

Multi-stakeholder models for education

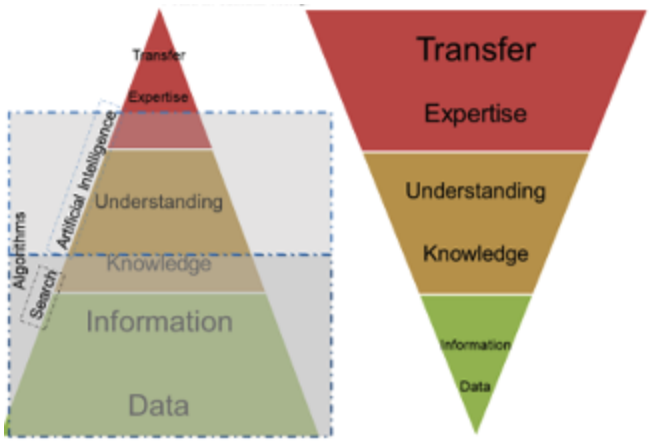
The burden of education and training may expand beyond the state. Employers may take on new roles to deliver retraining and upskilling for mid-career and professionals that already completed schooling. Programs that are funded and implemented in cooperation among the public sector, private sector employers, and potentially unions and employees themselves may be successful. Such programs would more directly match employers' needs with training programs. One example is 'apprenticeship' programs in Germany and Switzerland where employers support training during vocational schooling. Apprenticeships prepare graduates with concrete skills for the workplace, and are accredited in part for low unemployment rates in these regions. In cases of talent shortages, employers may offer upskilling programs to differentiate and attract the best talent.

Best practice examples from large companies in Europe which offer training programs to upskill current staff include the 'Engineer of the Future program at Airbus,' the 'Global Corporate Citizenship Programme' at IBM, and the Learning Factories 4.0 from Baden-Württemberg in Germany. However, for SMEs it may be more challenging to internalize costs for upskilling and training.

[15] See Endeavor VR.

Public-Private-Partnerships (PPPs) can bring cutting edge technological research from the private sector to public sector schooling. For example, Microsoft has partnered with Fresno school district in Fresno, California, to provide laptops and digital devices to young students in low-income communities.[16] The 'Personalized Learning Initiative' aims to prepare the high school class of 2030 with digital skills and 'digital literacy.' A key component is new teacher training programs to equip teachers to teach digital skills.

The Center for Curriculum Redesign (CCR) also proposes to "Flip the curriculum" for education in the age of AI. Instead of focusing on learning knowledge, which is easily accessed on the Internet and also can be manipulated with fake information and fake videos, it is important to educate for ability to 'transfer' learning and expertise from the classroom to new real-world contexts.



Source: Center for Curriculum Redesign

[16] Microsoft Education Blog.

Limits to education & training for job seeking and retention

There may be a limit to how much reskilling and upskilling can support workers from low-skill job categories. Automation is poised to first replace jobs in routine, predictable, and manual work. Consequently, low-skill workers may be hit hardest or first.[17] While technology may create new jobs, including professionals to manage AI networks, data scientists, cybersecurity experts and more, these jobs are likely to require high-skill education and background. It will be a challenge to re-train low-skilled workers to fill high-skill jobs, at least in the short and medium terms.

Moreover, rather than preparing one individual to compete with one machine on a task, we may expect groups of individuals to be systematically automated by large networks of machines. For example, it may be more efficient to replace all human drivers in a vehicle fleet with a new fleet of autonomous vehicles (AVs). Machine learning can optimize units in networks, such as a network of AVs in traffic AVs can communicate and coordinate via sensors and the cloud to operate efficiently and safely as a whole.

[17] Chang, J.-H. and Huynh, P. 2017. *ASEAN in transformation: The future of jobs at risk of automation*. International Labour Office (ILO).

Further Reading

Artificial intelligence, automation, and the economy, Executive Office of the President of the United States.

Alex Gray, "The 10 skills you need to thrive in the 4th Industrial Revolution," World Economic Forum.

Elliott, S. (2017), *Computers and the Future of Skill Demand*, Educational Research and Innovation, OECD Publishing, Paris.

Fadel, Bialik and Trilling, (2015), *Four-dimensional education: The competencies learners need to succeed.* Center for Curriculum Redesign.

Nicolas Miailhe & Cyrus Hodes, Making the AI revolution work for everyone, The Future Society, AI Initiative, Report to OECD, February 2017 – PART 3, CHAPTER D.

Nicolas Miailhe, Cyrus Hodes, Arohi Jain, Niki Iliadis, Sacha Alanoca and Josephine Png, (2019),
AI for Sustainable Development Goals, Delphi Special Issue, page 207.https://thefuturesociety.org/2020/02/13/ai-for-sustainable-development-goals/

Maya Bialik & Charles Fadel (2018), Knowledge for the Age of Artificial Intelligence: What Should Students Learn?, Center for Curriculum Redesign
https://curriculumredesign.org/wp-content/uploads/CCR_Knowledge_FINAL_January_2018.pdf

Niki Iliadis, (2018), 'Learning to learn, the future-proof skill", Big Innovation Centre, the Secretariat for the All-Party, Parliamentary Group on AI.
http://www.appg-ai.org/wp-content/uploads/2018/10/learning-to-learn_final_report_bic_kpmg.pdf

Wayne Holmes, Maya Bialik, Charles Fadel (2019), Artificial Intelligence in Education, Center for Curriculum Redesign.

World Economic Forum, (2016), *The Future of Jobs: Employment, skills and workforce strategy for the fourth Industrial Revolution.*

Annex 1: Potential impact that AI can bring to middle school teachers' job tasks

Task	Impact
Adapt teaching methods and instructional materials to meet students' varying needs and interests	High
Maintain accurate, complete, and correct students' records as required by laws, district policies, and administrative regulations	High
Prepare, administer, and grade tests and assignments to evaluate students' progress	High
Instruct through lectures, discussions and demonstrations in one or more subjects, such as English, mathematics, or social studies	Medium
Prepare materials and classrooms for class activities	Medium
Assist students who need extra help, for example through tutoring, and by preparing and implementing remedial programs	High
Assign lessons and correct homework	High
Establish clear objectives for all lessons, units, and projects, and communicate these objectives to students	Medium
Enforce all administration policies and rules governing students	Medium

Source: Tuomi, I. 2018. The Impact of Artificial Intelligence on Learning, Teaching and Education. European Commission and JRC Science for Policy Report. Publications Office of the European Union.