Trends Shaping Education Spotlight 15

A Brave New World: Technology & Education

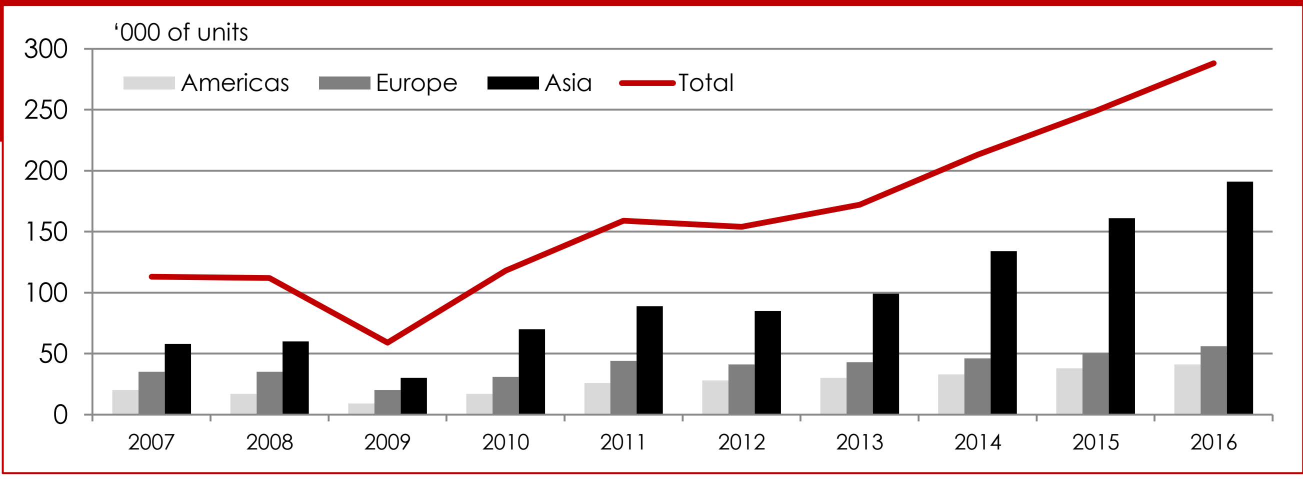
Rapid technological advances can have an impact on personal, social and professional development. Implications for education include changes in the demand for knowledge and skills as well as expanding possibilities for teaching and learning.

Growth of industrial robot demand

The increasing sophistication of robots, artificial intelligence, big data and the Internet of things (OECD, 2016a) generate anxieties about the automation of existing jobs. Although it might seem to be part of the distant future, the truth is that the number of robots, at least to take care of some tasks in certain industries, is already on the rise.

There has been a growing demand for industrial robots worldwide over the past decade (Figure 1). It is estimated that about 50 000 robots were supplied to the industry in 2007. Despite a slight fall in 2009, shipments have increased dramatically since then to almost 300 000 in 2016. Demand in the Asian region is the main driver of such trend. Robots are highly demanded in the automotive industry, followed by the electrical/electronics sector (IFR, 2017).

Figure 1. Estimated worldwide annual shipments of industrial robots by region, 2007-2016



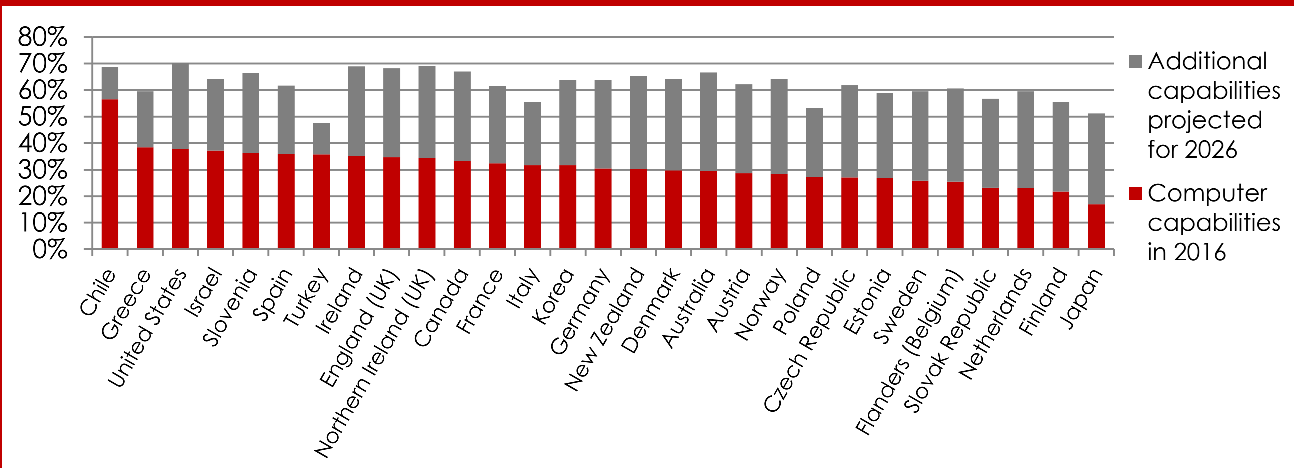
Note: The total figure is calculated by the sum of the three regions.
Source: International Federation of Robotics, https://ifr.org.

Technology, education and the future of work

Do new technologies make skills and knowledge acquired today obsolete for the future workforce? Scientific literature on technological development suggests that advances in computers' artificial intelligence, vision and movement capabilities could impact tasks carried out by the majority of workers in currently existing jobs (Elliott, 2017).

As shown in Figure 2, estimates suggest that computers are already able to perform literacy, numeracy and problem-solving tasks used today by many workers, particularly in Chile (over 50% of the workforce), Greece and the US. This is predicted to be the case across all OECD countries by 2026, with an impact ranging from nearly 50% of the workforce in Japan and Turkey up to 70% in Chile, Ireland, Northern Ireland (UK) and the US. This is not to say that computers can replace humans entirely, as computers are not yet able to match the diversity of skill sets that workers, even those with lower skills, use in their daily work.

Figure 2. Proportion of workforce using general cognitive skills with proficiency at or below level of computer capabilities (2016 and 2026)



Note: based on the combination of PIAAC data and computer scientists' analysis.

Source: Elliott (2017), *Computers and the Future of Skill Demand*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264284395-en.

Inferring future workforce implications is difficult: there are multiple economic and organisational factors mediating the application of technology in the economy. In addition, as computer capabilities evolve, so does the demand for skills in labour markets – demand of socioemotional skills, for example, has increased over the past four decades (Deming, 2017). In any case, if skills demand was to shift at the speed these estimates suggest, workers would have to continuously adapt their skill set over a working lifetime. This has major implications for education and training systems and underscores the importance of building students' adaptive capacity and developing robust systems for lifelong learning.

Skills demand and innovation: STEM and beyond

In recent years, many countries have paid increased attention to the fields of Science, Technology, Engineering and Maths (STEM). STEM fields are seen as closely related to national innovation capacity and widely valued across sectors in the economy (National Science Board, 2015). Potential shortages in STEM professionals have been flagged in several countries (e.g. OECD, 2017a), especially given the forecasts for increasing demand for jobs that require STEM skills.

Emphasis on STEM-focused educational programmes has risen internationally in response to these trends (Ritz and Fan, 2015). Programmes addressed STEM education across all levels of education, and experts reported that changes in teachers' education and training were already underway to support teaching in these fields. Perhaps surprisingly, conceptualisations of STEM were found to differ across countries; while some focused on improving learning in stand-alone subjects, others emphasised STEM as an integrative transdisciplinary approach to learning.

In fact, a single definition of STEM does not exist. In some contexts, STEM might include school subjects other than science, technology, engineering and maths, for example computer science and coding. It can also entail integration with subjects such as design, humanities and arts – the so-called STEAM movement (Freeman et al., 2017). Integrative approaches such as STEAM might better reflect the flexible thinking and transdisciplinary nature of real-life problem-solving and enhance students' motivation by providing them with multiple ways to engage in STEM learning. For integration to work, however, appropriate teacher training is needed to design pedagogical practices that work and effectively respond to the needs of individual learners.

Software education in South Korea

The 2015 revised national curriculum in South Korea reinforces software education to enhance students' capacity in a creativity-based society. With this goal, it emphasises the development of computational thinking, coding skills, and creative expression through software.

By the end of 2018, 60 000 elementary school teachers (30% of the total) will have received specialised training in software education. In addition, 1 800 middle school teachers who are certified to teach IT/computing will receive additional training.

For more information: www.moe.go.kr/

Interestingly, connection between STEM jobs and qualifications might be looser than often suggested; evidence shows multiple pathways towards STEM jobs other than STEM qualifications (National Science Board, 2015). Many highly-innovative jobs include individuals with diverse qualifications (Avvisati, Jacotin and Vincent-Lancrin, 2013), and even the most technologically advanced industries require pools of workers with complementary skills (OECD, 2017b). Education and training efforts should thus aim to develop diverse backgrounds and strong mixes of skills for students, including technical and cognitive and indeed metacognitive and socioemotional competence.

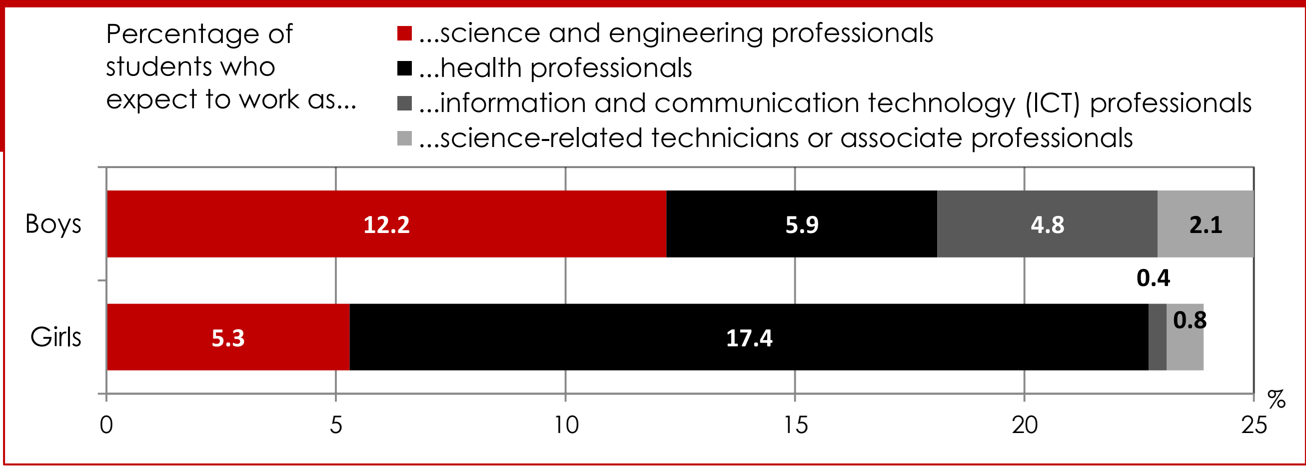
"Products must appeal to human beings, and a rigorously cultivated humanistic sensibility is a valued asset for this challenge" Damon Horowitz, In-House Philosopher and Director of Engineering at Google (17 July 2017).

Bridging gaps in fields of study and career expectations

One current policy concern is the large gender gap in enrolment for some math-intense programmes. In 2015, 50% of new entrants in natural sciences, mathematics and statistics tertiary-education programmes were women on average, but only 19% were in the fields of information and communication technologies, and 24% in engineering, manufacturing and construction fields (OECD, 2017c).

But gender differences start much earlier. PISA 2015 results (Figure 3) show that expectations of having a scientific or technical career greatly differ across gender. Twice as many boys as girls report expectations of pursuing a career as science or engineering professionals and technicians; the ratio grows to 10 to 1 when asked about careers in ICT. Conversely, girls are three times more likely than boys to report career expectations as health professionals.

Figure 3: Students' expectations of a STEM-related career, by gender (2015)



Source: Figure I.3.5 in OECD (2016), *PISA 2015 Results (Volume I): Excellence and Equity in Education*, http://dx.doi.org/10.1787/9789264266490-en.

> In PISA, gender differences in career expectations exist even at equal levels of science performance.

These different expectations exist regardless of the level of performance in science (OECD, 2016b). This suggests that social and psychological biases are playing a role, for example, through stereotypes or gender-related misconceptions of the abilities required in these disciplines (Wang and Degol, 2017). Evidence indicates that professionals acting as STEM role models can have a positive effect on students to override such trends (Shin, Levy and London, 2016).

Digital skills matter: Addressing risks, bridging divides

ICT use brings numerous advantages, such as greater connectivity and lower-cost for services, goods and information. However, these gains are not equally distributed and technology use comes with a number of risks. Building resilience to this is crucial.

Risks linked to digitalisation

Children face three main types of digital risks (Livingstone et al., 2011). *Content* risks refer to violent, hateful and pornographic content (Peter and Valkenburg, 2016), or commercial advertising masquerading as news. *Contact* risks include harassment, abuse and the compromise of personal data (Lupton and Williamson, 2017). Lastly, *conduct* risks include cyberbullying (Kowalski et al., 2014) and 'sexting' (Kosenko, Luurs and Binder, 2017).

The Internet of Toys

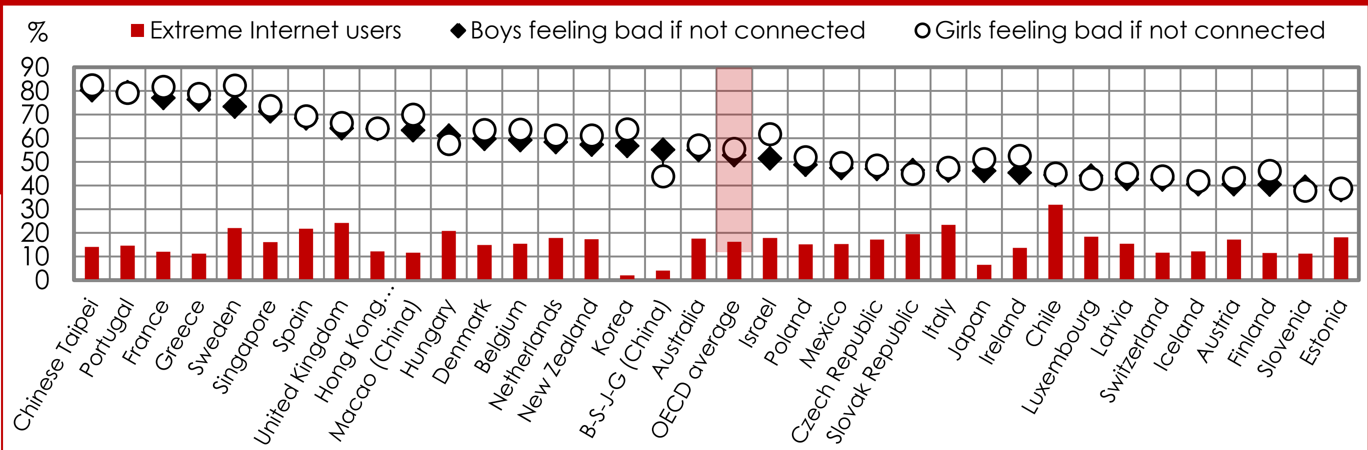
Software-based internet-connected toys provide with increased personalised playing and learning opportunities. All this comes along with growing concerns for data privacy, ownership and security, and potential negative effects on children's cognitive, behavioural and social development, such as decreased human communication.

For more information:
https://ec.europa.eu/jrc/en

These digital risks exist alongside risks to physical and mental health. Examples include separation anxiety, fear of missing out, decreased sleep quality and duration, poorer dietary habits and physical activity. Some studies also suggest links between ICT use and depression, ADHD, obsessive-compulsive disorders and hostility, although the direction of the link is not clear (Ashton, 2018; Galpin and Taylor, 2018).

The danger of these risks increases with the extent of dependency. As shown in Figure 4, about 16% of respondents in PISA 2015 were extreme internet users – those who connect to the Internet for more than 6 hours daily in a typical weekday – with the highest percentage reported in Chile, Italy and the UK. Over half of respondents reported "feeling bad" if no Internet connection was available. This feeling was most widespread in Chinese Taipei, France, Greece and Portugal (OECD, 2017d).

Figure 4. Children feeling bad if not connected and percentage of extreme Internet users (2015)



Source: Author, with data from Tables III.13.7 and III.13.16 in OECD (2017), *PISA 2015 Results (Volume III): Students' Well-Being*, http://dx.doi.org/10.1787/9789264273856-en.

It is important to identify which children are more vulnerable to digital risks and compulsive internet use in order to help protect them. Risk factors include (1) personality factors such as sensation-seeking, low self-esteem and psychological difficulties (acting both as causes and consequences of Internet addiction disorders), (2) social factors, such as the lack of parental support and peer norms, and (3) digital factors, such as specific online practices, online sites and skills (Livingstone and Smith, 2014; Anderson et al., 2017).

Digital use, skills and motivation

> The digital divide includes types of ICT use, level of skills and motivations.

Due to the progressive expansion of connectivity, digital divides are now more about use than access to technology. ICT use brings along numerous personal, economic, social and cultural outcomes, such as access to employment opportunities, rich and accurate information, and specific products and services, but not everyone benefits equally from it. Translating digital engagement into offline advantages strongly depends on individuals' concrete uses of ICT, digital skills and motivations, which in turn relate to contextual factors, such as social, economic and cultural status (ESCS)(Helsper, Van Deursen and Eynon, 2015; Helsper, 2017).

PISA data reflect this, demonstrating that a higher percentage of advantaged students use ICT outside of school for reading news (70%) or obtaining practical information (74%) in comparison to disadvantaged students (55 and 56%, respectively) (OECD, 2016c). With regards to skills, ESCS accounted for 12% of the variation on average across OECD countries in digital reading performance – for example, the ability of students to use navigation tools and locate pieces of information (OECD, 2015a). In relation to motivation, PISA 2015 data show that 93% of advantaged students think the Internet is a good resource for obtaining information, in comparison to 84% of disadvantaged students (OECD, 2017d).

Closing such divides is a key to levelling individuals' capacity for a successful personal, professional and civic development in a digital world. One challenge is that approaches to digital skills overemphasise the role of basic operational skills (e.g. how to install apps or use Internet browsers) despite indications that it is a combination of skills, including the social and creative (e.g. sense of self-efficacy in using social networks, capacity to create digital content) that generate positive tangible outcomes (Helsper et al., 2015).

Building digital resilience

At home, many parents use rules, time limits, and bans on particular activities or contents for their children to go online. These restrictive strategies are associated with fewer risks, but come at the cost of digital opportunities. Parents who are more confident of their own or their children's digital skills take a less restrictive approach and favour mediation strategies. By encouraging digital activity and sharing it with children, such parents create a safer environment without preventing use or hindering children's agency and learning, helping them better manage risk and learn when things go wrong (Livingstone et al., 2017). This suggests that interventions targeting the skills of both parents and children can increase children's resilience to risks and expand their opportunities.

Using rather than restricting ICT access supports digital resilience, but requires higher digital skills.

Schools can contribute to students' risk resilience in a number of ways. First, teachers can be trained on digital risks and their implications. Secondly, schools can foster a zero-tolerance culture to behaviours such as cyberbullying. Lastly, they can introduce online ethics and safety learning opportunities into the curriculum, offering spaces for adult and peer mentoring so that students can discuss practical implications of digital engagement and improve their levels of empathy and self-control (Harrison-Evans and Krasodomski-Jones, 2017; Hutson, Kelly, and Militello, 2017; Döring, 2014).

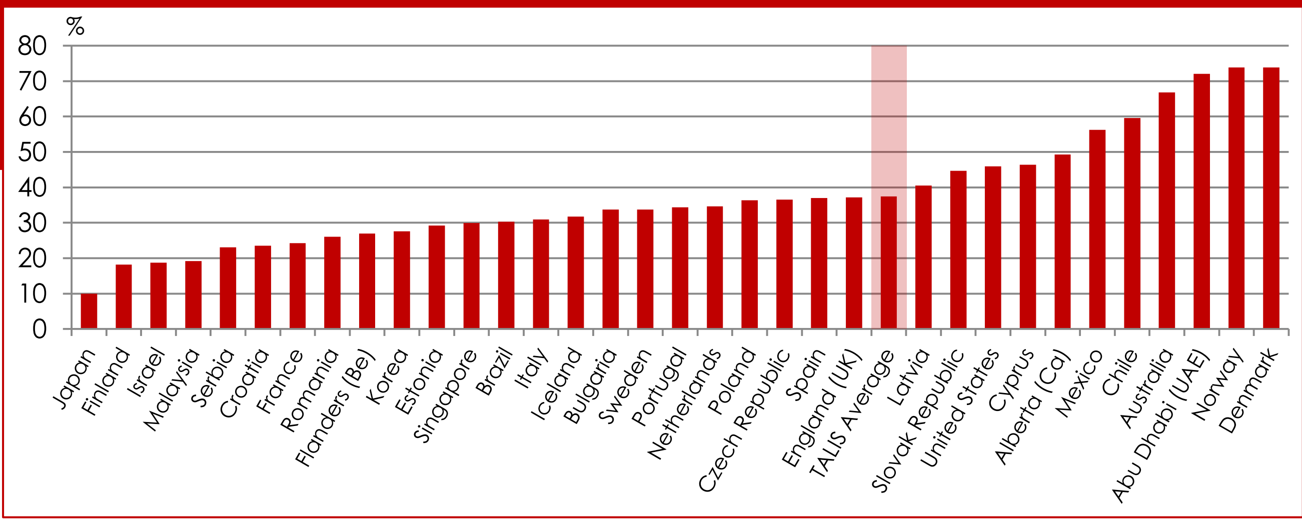
Technology for teaching and learning

Children usually have higher access to technology and tend to use it more for learning purposes at home than in school (OECD, 2015a). Yet, ICTs are present in more and more classrooms across OECD countries in an increasing variety of forms. In fact, the diversity of devices increases as bring-your-own-device policy spreads across schools.

Technology use and educational outcomes

The impact of technology on student achievement and interventions aimed at improving communication of teachers with peers, students and families have been widely researched. Overall, evidence shows little if any effects of increased access to equipment and educational software in schools (Escueta et al., 2017), and improvements are comparable to other types of offline interventions, such as improving feedback to students and peer-learning (Higgins, Xiao and Katsipataki, 2012). In fact, as shown in Figure 5, less than 40% of teachers report using technology for students' projects or class work. This is less than 20% in Finland and 10% in Japan, both PISA high-performing countries.

Figure 5. Teachers' use of ICT for students' projects or class work, 2013



Note*:* Data from the United States are not included in the calculations for the international average. This is because the United States did not meet the international standards for participation rates.

Source: Figure 1, in OECD (2015), "Teaching with technology", *Teaching in Focus*, No. 12, http://dx.doi.org/10.1787/5jrxnhpp6p8v-en.

This is not to say that technology cannot support student learning or add value to traditional instruction. For example, positive effects have been observed in using modern intelligent tutoring systems, i.e. adaptive one-on-one learning software mostly used for drill-and-practice (Ma et al., 2014).

Blended pedagogies bringing together online and offline instruction (e.g. "flipped classroom") are already increasingly used. Interesting developments in gamification, using technology to enhance the scope and immediacy of the game, are also emerging. The key is finding the right interplay of the different elements that influence student learning, including the learning goals, specific technologies available, students' prior knowledge and learning needs, teachers' professional competence and the context in which teaching and learning develop (Paniagua and Instance, 2018).

This is more easily said than done, however. Leveraging the rapidly growing potential of educational technologies often implies reorganising common teaching practices and rethinking teachers' role in the classroom. In fact, a number of important elements must go along with the introduction of technology in order for its potential to be realised.

> It is the pedagogy of technology application rather than technology itself that makes a difference.

First, the level of confidence and digital skills of teachers and students in using ICT must be taken into account. Second, effectiveness of ICT in the classroom depends on how it is used – having access to it is not enough. The actual use that teachers make of technology and their ability to integrate it into their teaching to further their learning goals is what counts (Comi et al., 2016).

Technology integration and teachers' professional development

Effective integration of technology into classrooms requires technological competence and confidence. In a context where 59% of teachers report either a moderate or high-level need of professional development in using ICT for teaching (OECD, 2015b), efforts are needed to make this possible. First, competence requires time for day-to-day trial-error practice. A teacher, or anybody else for that matter, cannot become an expert in a particular digital tool overnight. Second, pedagogical, technological and content knowledge must come together to address the particularities of students and learning contexts (Harris, Mishra, and Koehler, 2009). Last but not least, teachers' attitudes to technology are crucial. The perception that technology will be of any benefit during the course of instruction is intimately linked to its adoption and use (Ertmer and Ottenbreit-Leftwich, 2010).

> Teacher knowledge, confidence and beliefs are crucial to technology integration.

Professional development should target the overall school culture, providing time for professional practice, collaboration and identification of what works. To this end, effective strategies include 1) teacher training programmes focusing on skills development by using, 2) increased teacher collaboration and 3) peer mentoring (Davies and West, 2014).

The potential of EdTech continues to grow

Technological development continues to advance low-cost and innovative applications for a more personalised and engaging teaching and learning. For example, virtual learning environments such as videogames, simulations and virtual worlds can better motivate students in their learning, facilitate situated-learning experiences that were not possible before (e.g. small schools in remote regions), and generate new avenues for interacting with others to practice particular skills (Merchant et al., 2014; OECD, 2016e). Examples may include dissecting animals in a virtual lab or practice certain skills within real-life virtual situations.

Also, digital learning systems that adapt content to students' individual responses are improving their capacity by building on cloud computing and educational data mining (Oxman and Wong, 2014). As these systems upgrade and find their way to the classroom – being integrated in learning management systems, for example – teachers can free up time to better plan activities and enhance feedback to students. Increasingly, advances in artificial intelligence will further allow for wider, more refined assessments, such as recognising students' emotional reactions to the task at hand and open new ways to facilitate student collaborative learning (Luckin et al., 2016).

Additionally, technology can be leveraged to reach out to parents and students more effectively. There are a number of existing successful examples already. These include text messages to parents to engage them in children's learning by informing them about the number of missed classes, providing students with career guidance and relevant tips for college admission, or "mindset messages" to help pupils reflect positive attitudes towards themselves, their peers and the school. These are low-cost and effective interventions that yield positive results (Escueta et al., 2017). For teachers and school leaders, using technology (text messages, platforms and social networks) to make sure both parents have access to scholastic information and news about their children is efficient, and especially useful to ensure the information is transmitted in cases of divorce where parents are reluctant to coordinate together.

Keeping in touch with parents (Chile)

The intervention *Papás al Día* in Chile sends weekly text messages to parents of almost 1,500 students in grades 4 through 8 to inform them about student absenteeism, grades, and behaviour in the classroom.

After four months, treated students had improved math grades, reduced bad behaviour, and obtained higher rates of grade progression.

For more information:
www.povertyactionlab.org

Towards the future

In the next decades schools will most likely continue to be one of the main venues for children's initial socialisation and acquisition of basic knowledge and skills. Nevertheless, as classrooms become more and more technology-rich environments, the way students learn and teachers teach could transform radically. Technology mirrors and sometimes magnifies the risks we face as well as the opportunities we have at our disposal. Building resilience to the former and grasping all the benefits of the latter are among the fundamental challenges education faces today.

Improving teaching & learning

- equiping teachers with sound pedagogical and technological knowledge
- supporting more personalised and engaging learning

Building digital resilience

- developing digital competence
- using appropriate digital mediation strategies at home and school

Providing skills for the future

- developing the higher-order thinking and social and emotional skills that a digitalised and automated world requires

Questions for future thinking

1. Imagine robots have fully taken over jobs and now humans can spend their time doing what they please. Assuming they would still value the institution of public education, what kind of knowledge and skills would human beings need in a post-work world?

2. As the pace of technological development accelerates, what kind of risks do you think will become more present in the years to come? Are we paying sufficient attention to them already?

3. If we consider an education model in which computers could replace teachers and learning took place fully online with no trade-offs, would schools completely lose their raison d'être? Would the answer be the same at different levels of education?

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