WHAT TECHNOLOGY CAN AND CAN'T DO FOR EDUCATION

A COMPARISON OF 5 STORIES OF SUCCESS

Edited by
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FOREWORD

The world faces complex challenges that require immediate action, including climate change, rising migration, new demographic and employment configurations, inequality, and the need to rethink governance to ensure a sustainable future. Exponential technological advances are helping people join forces to solve global issues in a collaborative, creative manner, with the opportunity to scale innovations and generate huge impact.

In many countries, the digital era has opened a new learning space that can be accessed by anyone at anytime from anywhere. Not all regions of the world have universal connectivity. At least half the world's population still lacks access to the Internet and the vast benefits it yields.[1]

Leaders must work collectively to eliminate the digital divide—not merely by granting access to technology but rather by using and mastering its different dimensions. Are people using information and communication technology (ICT) to create or consume content? Are they able to program or be programmed by computers? Are they using social media in ways that help them detect misinformation and become digital citizens? These are some important questions that can help determine whether people will be observers of or protagonists in the Fourth Industrial Revolution.

Technology yields many benefits, but it also exposes people to threats and ethical dilemmas. Widespread adoption of ICT alongside globalization has led to the emergence of new issues that need to be addressed, including tech addiction, privacy breaches, and the need to adjust business models in response to industry disruptions and automation.

Mario Abdo
President of Paraguay

Every country should be rethinking its education system in light of the risks and opportunities of ICT. Children are eager to explore and discover new cultures and can now easily access vast repositories of content or connect with field experts to pursue their passions. Students can benefit from personalized learning environments that incorporate artificial intelligence, gamification, big data, and virtual reality. With adaptive software, educators can understand how every child is performing and evaluate student's progress in real time while providing customized resources.

Schools require systemwide adaptations with the introduction of technology. Teachers have to shift from being instructors to becoming mediators in the classroom. In some places, student's addictions to technology is correlated with rising anxiety and depression. Parents are also learning how to monitor and participate in their children's digital life. School administrators and ministries of education are redefining the roles of formal versus informal education settings, given the change in learning paradigm that must occur to prepare students for the future.

Governments must provide institutional and policy frameworks to take advantage of the knowledge economy and raise living standards. Leaders in Paraguay understand that technology must be part of a broader development strategy. Paraguay is enjoying a demographic dividend, as 70 percent of the population is below the age of 35. Paraguay also ranks first in the world on Gallup's index of positive emotions.[2] One of the questions

1• www.weforum.org/projects/internet-for-all

the Gallup survey asked to participants in 140 countries was "Did you learn or do something interesting yesterday?" If policymakers do their jobs to ensure the quality and relevance of our education systems, all students everywhere will proudly answer "Yes!"

Introducing technology to reform education is essential to leapfrog certain development stages. With the support of the Inter-American Development Bank, in October 2018 Paraguay organized a seminar on the "Future of Learning with Technology," to learn from the experiences of Ecuador, Estonia, Finland, the Republic of Korea, and the United States. All of the case studies analyzed during the seminar concluded that technology is a powerful tool for education when there is a shared vision that identifies the critical steps needed to achieve a shift in the learning paradigm. In this context, Paraguay's national authorities signed a declaration to guarantee children access to technology in order to develop 21st century skills.

United Nations Resolution 65/309, adopted in 2011, establishes that human happiness should be a universal maxim. The resolution has driven countries to rethink development in a more holistic way: the feelings and emotions of citizens are more important than traditional economic indicators of progress, such as GDP. Paraguay is currently carrying out fiscal, education, and health reform and investing in universal connectivity and policies aligned to the Sustainable Development Goals (SDGs). The overarching aim is to provide an enabling environment in which people can flourish and become part of a global movement that promotes the advancement of well-being, prosperity, peace, and protection of the planet.

Mario Abdo
President of Paraguay

2• www.weforum.org/agenda/2018/10/paraguay-is-the-most-positive-country-in-the-world/

PREFACE

*What happens if schools are closed?
Learning must continue. How can
students learn without a teacher
physically present? How can teachers
reach students who lack technology at
home? How can schools provide lunch?
How can student learning be assessed?*

Marcelo Cabrol
Manager of Social Sector
Inter-American Development
Bank

These are just a few of the mindboggling questions that education systems around world are confronted with amid the coronavirus outbreak that kept more than 1.5 billion learners out of school in the spring of 2020. The questions resemble "assumption reversal" exercises—in which a group choses a notion, reverses it, and comes up with solutions to tackle the problem raised—a technique often used in the creative industries to provoke unconventional thoughts and design innovative products. Uber, for instance, is an example of a solution to the reversed notion of "what if taxi companies do not own taxis?"

The massive disruption caused by the coronavirus pandemic has challenged education systems around the world. Innovation is no longer just an activity but a fundamental tool with which to address a reversed reality. Systems are forced to solve a conundrum in which students of all ages, locations, and family backgrounds must continue learning outside of school. For the most part, what they have as a response mechanism is 150-year-old structures that many systems have resisted changing, despite poor student achievement and mismatches between what work and life demand in terms of skills and what students develop in schools.

Many governments, including in Latin America and the Caribbean, have resorted to technology to address these challenges, choosing options based on their constraints in infrastructure and connectivity. Among the 23 countries in the region that closed schools because of COVID-19, more than half delivered education via radio and TV, and made digital contents available. Only Uruguay was able to transition to virtual classrooms.

Will these adjustments mark the beginning of much needed reform processes that will lead to a new normal? In the aftermath of the outbreak, will countries that lagged in technology jump on the bandwagon of education reform and begin heavily wiring classrooms? If so, this will mimic the efforts undertaken by many advanced economies at the turn of the century. By 2012, the average student-per-computer ratio in the OECD countries was reduced to 4.5 to 1, and Australia and the United Kingdom achieved ratios of one computer per student. A word of caution however is that these technological installments alone do not necessarily translate into improvements in learning. Indeed, many countries that invested heavily in technology for education have shown no appreciable improvements in the Programme for International Student Assessment (PISA) test scores in reading, mathematics, or science.

Some countries did transform their education systems and, most importantly, the learning of their students—by widely, but not exclusively, incorporating technology. Countries like Estonia, Finland, and the Republic of Korea leapfrogged in performance and learning results in the past few decades. These countries invested heavily in expanding digital access, but their education reforms were led by a clear new vision for education, a review of the national curriculum, inclusion of new ways of learning and teaching, and continuous teacher training, which together optimized the technological improvements in the education system.

Technology does not fail education. It is us as policymakers, teachers, educators, and parents who fail to make the most out of technology for education. Most countries have not been successful at using technology and providing teachers and students with the tools they need to make effective and ethical use of technology. The full potential of technology to provide overdue solutions to challenges in education such as inequality, teacher quality, and skills mismatch has not been harnessed.

"We must discuss not where technology is taking us but where we are taking technology," said Malta's Minister of Education and Employment in a recent interview. This book echoes and extends his observation. It examines the preconditions and enabling environments needed for technology to work and produce substantive changes and advancements toward quality education for all. It analyzes education systems around the world that have been extremely successful not just at integrating technology but also at producing massive improvements in student learning outcomes.

Many countries are transforming their education systems in an effort to be more resilient to crisis and equip their students with the skills they need to thrive. We hope that the lessons reflected in this book will serve as a useful reference for them—and ultimately contribute to achieving more prosperous societies.

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Convinced of the value of investing in people to transform societies, Mercedes Mateo Diaz leads and contributes to the research, design, and execution of innovative education projects. She coordinates IDB's 21st century skills initiative, a multidisciplinary group developing effective solutions to help individuals of any age cope with an increasingly digitized world, reinvent themselves throughout their work lives, and coexist with different people and environments. Her work covers various areas of international development and social policy, with a strong emphasis on inequality. Mercedes joined IDB in 2004. Between 2002 and 2004, she was a postdoctoral research fellow and honorary researcher at the Belgian Scientific Research Foundation (FNRS). In 2002 she was awarded a Marie Curie Fellowship at the European University Institute.

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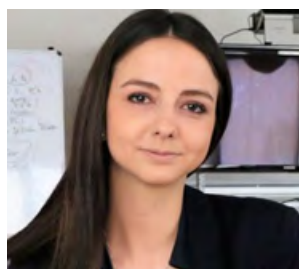
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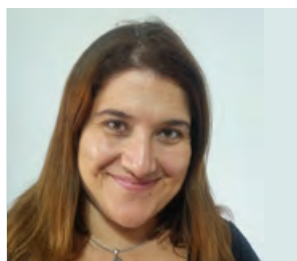
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PART
01

Preparing Students for New Challenges

Chapter 1

Mercedes Mateo Diaz and Changha Lee

A Silent Revolution

Mercedes Mateo Diaz and Changha Lee

Technology has probably never been in such great demand for education. As a consequence of the rapid spread of COVID-19, schools in 192 countries were closed and 91 percent of children and youth were sent home in the spring of 2020 (UNESCO 2020). The entire world is suddenly engaged in the biggest distance learning experiment in history. Technology is no longer a peripheral instrument that is good to have or makes education more efficient and effective; it is a core medium that allows education to happen and continue amid crisis. Technology had been an enabler of education. Suddenly, education depends on technology.
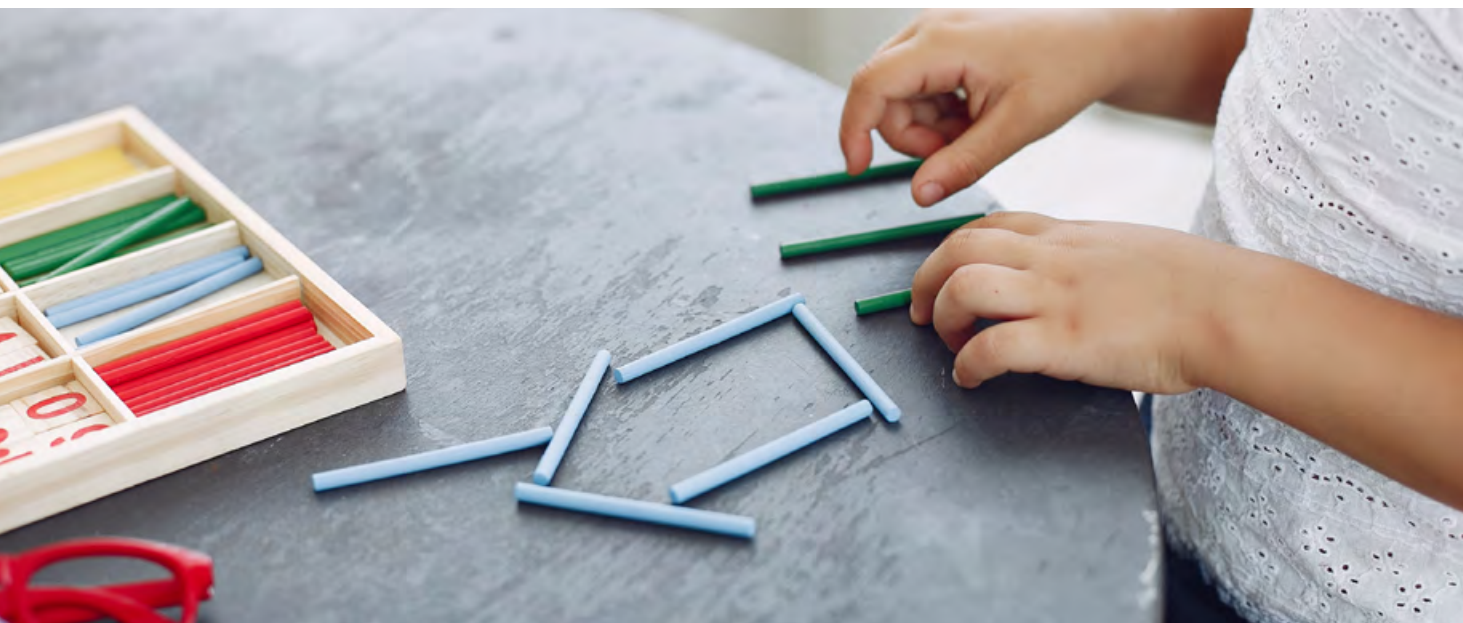
Education systems around the world have identified multiple channels of technology that can reach and teach students and connect teachers and students so that education can continue while school buildings are closed. Depending on the level of connectivity and the level of information and communications technology (ICT) infrastructure in the country, governments opted for and incorporated radio, TV, social media, and digital learning platforms to ensure continuity and mitigate the potential loss of learning (Cobo, Hawkins, and Rovner 2020).

In Latin America and the Caribbean (LAC), radio and TV have been the most common technologies used to reach students and deliver education. According to a review of the 23 countries in LAC that closed their schools because of the pandemic, 74 percent used radio and TV, 52 percent made digital contents available, and 35 percent combined textbooks with social media to continue learning during the crisis (Vasquez et al. 2020). Only Uruguay was able to move schools online with digital platforms that cover school curriculum and allow teachers to communicate with students and monitor their learning progress (IDB 2020).
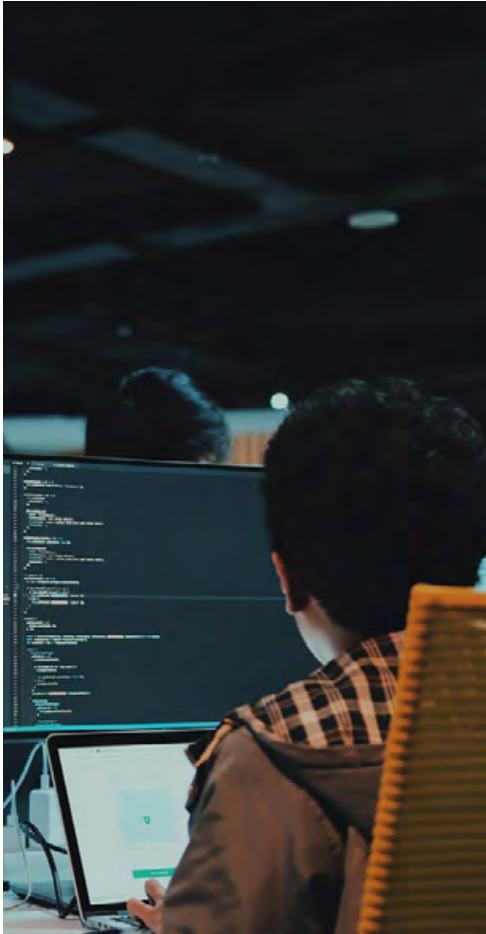
Crises afflict everyone, but they hit the most vulnerable hardest. How will pandemic-related school closures affect learning loss, and how will the losses differ based on students' family backgrounds?

One clue could be the literature on "summer loss," which measures how much students deteriorate in math and reading proficiency after a long summer break (Cooper et al. 1996; Busso and Camacho Munoz 2020; Mateo 2020). On average, children from low socioeconomic backgrounds lose three months of learning. In contrast, some students from high socioeconomic background improve their math and reading skills over the summer (Busso and Camacho Munoz 2020).

These differences may show up because of the novel coronavirus. According to a survey of 1,700 educators across the United States, the absentee rate was 1 in 10 students in affluent communities but 1 in 3 students in high-poverty communities (Kurtz 2020). Students from these communities were absent not only because they lacked connectivity and infrastructure but because the crisis amplified the multifaceted obstacles associated with poverty, such as lack of parental support and supervision and the need to perform household chores, including babysitting siblings (Goldstein, Popescu, and Hannah-Jones 2020; Scheiber, Schwartz, and Hsu 2020).

Evidence from LAC paints a similar picture for students from low-income backgrounds (Busso and Camacho Munoz 2020). According to data from the 2018 Programme for International Student Assessment (PISA), less than half of students from low socioeconomic backgrounds in the region lived in an environment that was ready to engage in remote learning. Only 30 percent had computers for schoolwork, and less than half had Internet access; almost all students from wealthier backgrounds had access to computers (95 percent) and the Internet (98 percent). Of course, material and technological support are only one of the inputs students need to learn. Support from parents and teachers is also needed to encourage and supervise student learning.

Technology is a powerful tool, if not the only tool to ensure the continuity of learning during a time of emergency. In normal times, it allows educators to scale up interventions and reach commonly excluded or poorly served populations at a lower cost. But technology is not a panacea to all problems education systems encounter. Only a few educational systems have been able to leverage technology to improve learning and better respond to the potential learning loss during the pandemic. No country prepared for this crisis, but some seemed to experience less damage than others. Why? What can other countries learn from them?

This book addresses these central issues. It does not examine specific programs or solutions that incorporate technology or investigate education responses amid crisis. It does examine transforming education for the new normal and the systematic changes it requires. It looks at systems in which technology is plugged in as part of a whole. It presents an overview of successful cases and discusses the enabling factors. The book's chapters illustrate through different experiences and pathways that transforming education is not just about bringing in technology. It is about adopting a new vision and making the systems more flexible and adaptable to new circumstances.

The current pandemic is only a prelude to what the 21st century will look like. Abrupt, disruptive changes—not only in the form of global health crisis but also related to other challenges, such as climate change, migration, and trade wars—will occur again. The world needs to learn to respond more effectively to this new normal. This chapter discusses a different way of living, working, and developing the future generation in the 21st century and shows what technology can contribute.

A Global Change:
A Different Way of Living and Working

We are living in times of unprecedented changes. Together with inequality and low social mobility, individuals are facing challenges unique to this century in the way and degree to which new dynamics caused by artificial intelligence (AI) and automation, aging, climate change, and migration are occurring. Advancements in technology such as robotics, AI, genetics, machine learning, and related technologies have expanded possibilities for human beings and signaled big changes in society. The digital economy is increasing productivity, wealth, and well-being in more ways than traditionally measured (Brynjolfsson and Collis 2020).[3]

Autonomous driving, fully automated manufacturing, and home care delivered by robots are no longer scenes from science fiction movies (Grote and Kochan 2018); industries around the world have adopted and capitalized on these technological breakthroughs. Thanks to a substantial drop in their unit prices, the estimated supply of industrial robots grew more than fivefold over the past two decades, rising from 69,000 units in 1998 to 381,000 units in 2017. Robots are particularly prevalent in high-tech economies and in the manufacturing and construction sectors (World Robotics 2018).[4]

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[3]• Brynjolfsson and Collis (2020) argue that traditional metrics such as GDP or productivity fail to capture the Internet's contribution to the economy, because important digital services such as Google, Facebook, LinkedIn, Skype, and Wikipedia are provided for free. Based on their research and estimates, a substantial increase in well-being has gone uncounted.

[4]• The five countries with the highest robot density include Korea, with 631 installed industrial robots per 10,000 employees in the manufacturing industry; Singapore (488); Germany (309); Japan (303); and Sweden (223). The world average was 74 (World Robotics 2018).
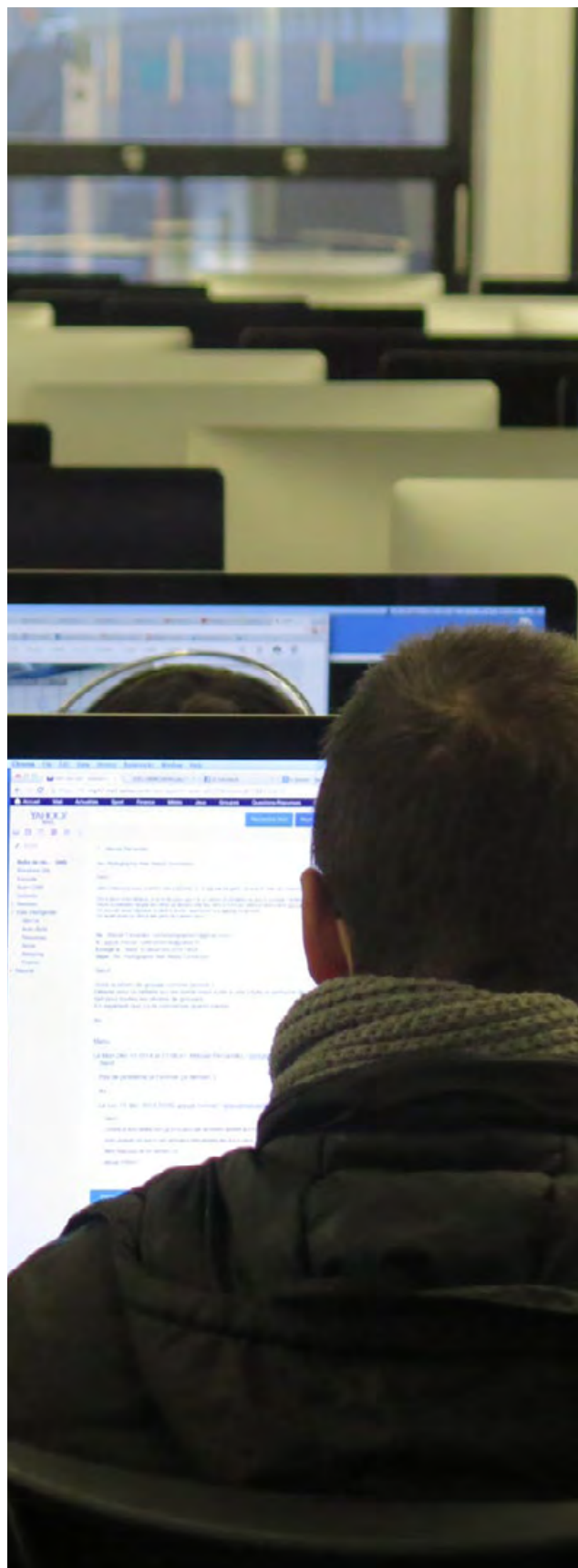
Companies have progressively reduced the costs of production and replaced low-wage labor with predictable and efficient machines (West 2018). Compared with the 1960s, the market capitalization of today's top firms has increased by a factor of 10–100. In contrast, the number of employees is, in some cases, less than a fifth what it was. In 1962, AT&T, the largest U.S. company at the time, had 564,000 full-time employees and a stock market capitalization of $20 billion in current dollars. In contrast, Apple, the leading business in 2017, had a capitalization of $800 billion and employed just 116,000 people, and Google, with a market value of $680 billion, had just 74,000 full-time workers (West 2018).

Technology has displaced millions of workers, particularly in low-skilled and routine occupations (Ford 2015). But it is also creating jobs that did not exist before (WEF 2020). It is estimated that 65 percent of children entering elementary school today will hold jobs that do not yet exist (WEF 2016). Jobs like telemarketing and tax preparation, which involve systematically processing large amounts of predictable data, have progressively been automated (Frey and Osborne 2017). At lower risk of automation are high-skilled workers in the digital sectors, as well as teachers, health care professionals, and other workers who interact with people and people whose jobs require higher-order skills, including creativity, negotiation, communication, and leadership skills (Ford 2015; Frey and Osborne 2017; Robles et al. 2019).

The volume of high-technology exports doubled between 2001 and 2014 (World Bank 2018). During this period, the Republic of Korea and Singapore expanded their volume by factors of two to three, joining the top five countries on the Bloomberg Innovation Index (Jamrisko and Lu 2018). Behind these countries' success are some commonalities: heavy investments in high-tech research and development and the development of a critical mass of individuals with the skills needed to make technological improvements.

Twenty-First Century Skills:
A Different Way of Developing Talent

Accelerated environmental, demographic, and technological changes in the 21st century are reshaping the social, economic, and political order. The COVID-19 pandemic, for example, calls for a tightening of the global network; a high level of leadership and communication skills by the government; and the reinforcement of self-discipline, empathy, and unity among individuals. The 21st century is reconfiguring society, forcing educators to rethink the way they develop and train individuals.

Amid this rapid change, many education and human capital formation systems are not ready to support and equip students with the skills they need to succeed in the digital era. Schools often stick to a 20th century mass production model and train young people for the jobs of the past (Nakagawa 2015; Beard 2018; West 2018). They need to readjust to allow individuals to upskill, reskill, and learn how to learn for the rest of their lives. Doing so requires a deep change in focus and the incorporation of new ways of teaching and learning (Cabrol 2019).

A recent report by the Organisation for Economic Co-operation and Development (OECD) suggests that schools are preparing students for a world that no longer exists (Mann et al. 2020). Youth with more years of education than ever before struggle to find jobs at the same time that companies have difficulty finding employees with the profiles they need. Students lack the mindset and tools to adjust to a new reality. There is a disconnect between the range of jobs that exist and are in high demand today on the one hand and young people's awareness of changes in the labor market and new possibilities on the other. Although technology has disrupted the world of work, youth still dream of 19th and 20th century occupations. And the set of job choices narrows for girls and people from disadvantaged backgrounds (Mann et al. 2020). Socioeconomic status and gender biases in science and engineering continue to be strong predictors of choices and career aspirations.

To face these challenges, individuals need to be equipped with a set of foundational skills that will help them not just compete in the labor market but grow and achieve higher levels of welfare throughout their lives. Education is a very important predictor of labor market outcomes, including access to good-quality jobs, labor income, successful labor trajectories, and welfare. But it is the acquisition of skills that matters, not the mere accumulation of years of education.

Providing people with foundational skills throughout their lives is the best buffer against uncertainty. Socioemotional skills such as empathy, adaptability, perseverance, and resilience are more important than ever amid crisis. Other foundational skills include, but are not restricted, to digital skills; advanced cognitive skills such as teamwork, communication,creativity, critical thinking/problem solving; and the ability to pursue lifelong learning. None of these skills is new, but they are now critical.

A 2018 McKinsey report that studied 15 Western countries identifies the skills that are likely to experience the largest shifts in demand between 2016 and 2030. It projects about a 15 percent decrease in the hours spent on basic cognitive and physical and manual skills (such as basic data input and processing, basic literacy, numeracy, and general equipment operation) and an 8–55 percent increase in demand for higher cognitive, socioemotional, and technological skills (Bughin et al. 2018).

To thrive in the 21st century, students need to develop skills for human interactions, such as communication, negotiation, and collaboration; creativity; problem solving; and critical and analytical thinking (Ford 2015; Nakagawa 2015). To help them do so, education systems need to restructure the curriculum, include new ways of student learning, update the role of teachers and teacher practices in the classroom, and ultimately provide education that is aligned with the technologically advanced society of the 21st century. Along with traditional basic skills (literacy and numeracy), foundational or transversal skills are essential if individuals are to lead healthy, productive, and happy lives. These skills are reusable, because they are widely transferable from one area of life to another rather than associated with a specific job, task, sector, discipline, or occupation. In international assessments, countries like Korea rank among the top performers not only on literacy and numeracy but also on many transversal skills, such as critical thinking, problem solving, creativity, and ICT literacy. Countries like Chile, Brazil, and Colombia rank in the bottom 5th percentile across many sets of skills (WEF 2015).

Transversal skills go beyond work. They are the equivalent of a person's operating system. These skills have a positive impact on individual and collective well-being. These foundational skills help individuals learn to self-regulate, be more empathetic and resilient, persevere, adapt to changes, gain self-confidence, and increase their expectations for their future. A growing body of evidence also shows an association between socio-emotional development of individuals and school commitment; academic and professional performance (Duckworth and Seligman 2005; Duckworth et al. 2007; Durlak et al. 2011; Heckman and Kautz 2013; OECD 2015); and other positive outcomes for both individual and collective well-being with respect to health, violence, and criminal behaviors (Durlak et al. 2011; Heckman and Rubinstein 2001; Heckman and Kautz 2012; AEI and the Brookings Working Group on Poverty and Opportunity 2015; Herrera et al. 2015; OEC 2015; WEF 2016; Case and Deaton 2017; Kankaraš 2017; Chernyshenko, Kankaraš, and Drasgow 2018). These skills are foundational because they are the pillars on which individuals can build productive and healthy lives.

Technology for Education

The average person in the United States is expected to change occupations about 12 times over the course of his or her life (Bureau of Labor Statistics 2019), and several of the occupations in greatest demand did not exist a few years ago (WEF 2016). Education systems must therefore prepare children for jobs that do not exist today. These are just two of the important trends that are challenging traditional education and training systems. Robots are replacing humans not only in routine and low-skilled occupations but also in more sophisticated jobs. Recently, for example, a machine-learning algorithm for contract review outperformed 20 experienced U.S. lawyers at identifying risks in nondisclosure agreements (LawGeex 2018). The algorithm achieved an accuracy level of 94 percent versus 85 percent average for the lawyers, and it took the program 26 seconds to perform the task that took the lawyers 92 minutes on average to perform.

Individuals will need to persevere, adapt, resist, stay curious and motivated to start again, learn new jobs, and discover new concepts and ideas. It is imperative that people develop new capabilities throughout their lives, stay abreast of the latest developments, and engage in lifelong learning (West 2018). In this context, technology is not just a challenge, it is also an opportunity to adapt learning, improve pedagogical practices, measure and certify new skills, reduce costs, expand access, and increase the effectiveness of learning. Indeed, many of the education and training alternatives that exist today would have not been possible before, because there was no technology to support them.

Beginning in the early 1980s, some countries engaged in education reform (Cuban 2001), based on the belief that technology in education would make schools more productive and efficient. As West (2018, 119) notes:

> Wired classrooms and electronic instructional sets let pupils learn at their own pace and in their own manner. Personalization makes education more adaptive and timely from the student's standpoint and increases the odds of pupil engagement and mastery of important concepts. [Moreover] it frees teachers from routine tasks and gives them more time to serve as instructional coaches for students.

Integrating technology into education has been a partial success. Many reforms were led "in the belief that if technology were introduced to the classroom, it would be used; and if it were used, it would transform schooling" (Cuban 2001, 13). After two or three decades of strong promotion of technology, computers have become more and more common in schools. But many of the other pieces—including curriculum, student learning, and teaching pedagogy, which together define the quality of education and determine a successful reform—have remained largely unchanged
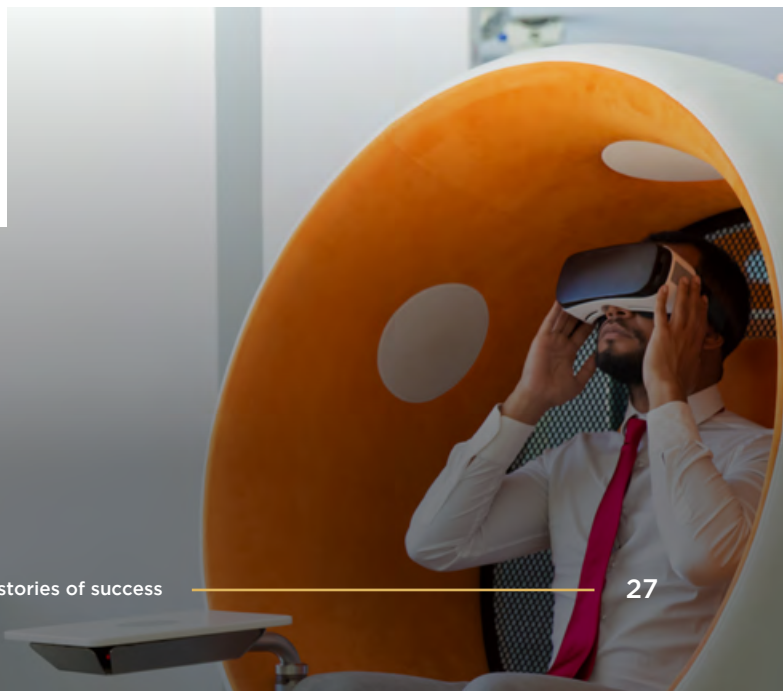
In the last decades, investments in EdTech have been significant around the world. What has been learned so far? A report by the Abdul Latif Jameel Poverty Action Lab (J-PAL 2019) reviews 126 rigorous studies of technology-based education interventions.[5] It analyzes the effects of four types of applications: delivery of technological infrastructure alone, computer-assisted learning, school–family communication, and online courses. It finds that programs that simply provide computers and Internet connectivity without doing anything else do not seem to improve academic outcomes, although they do increase computer usage and computer proficiency—a not insignificant achievement given the growing need for digital skills in increasingly technology-based societies.

Another important aspect of EdTech is the potential to adapt the learning process to different student levels within the same classroom through personalized instruction. Computer-assisted learning programs and educational software programs have proven effective at helping students improve their learning outcomes, particularly in subjects like math.

Parent involvement in the educational process and communication within the school community is important. Technology has been used to facilitate interactions between school and families. Simple measures such as text message reminders and nudges can have small but significant effects on educational outcomes at very low costs.

In the aftermath of COVID-19, the global expansion of distance learning will generate much knowledge about what works well and what needs improvement in EdTech. The aforementioned report by J-PAL emphasizes the lack of evidence of different modalities of virtual education on student learning outcomes, despite the rapid expansion of online content. There is a pressing need for more rigorous studies. Current findings from studies that compare pure online courses with in-person courses suggest that students taking the course online have lower student academic achievement, but that blended approaches (with in-person and online components) seemed to yield results that are comparable to pure face-to-face classes. This finding is very promising, because blended courses are much less expensive than in-person courses. The four applications highlighted in the study can be combined. For example, the use of nudges and behavioral interventions can increase students' completion rates in Massive Open Online Courses (MOOCs) (J-PAL 2019).

Technology has opened the door to new ways of learning. Videogames, for example, have traditionally been viewed as detrimental to the development of children and youth. But growing evidence indicates that when properly used, gamification can support learning in both traditional subjects/basic skills and the development of 21st century skills through learning by playing (Michael and Chen 2005; Blumberg, Rosenthal, and Randall 2008; Granic, Lobel, and Engels 2014; Mateo Dias and Becerra 2019; Araya et al. 2019). Common criticism of videogames is that they are addictive, promote violence and aggressive behaviors, and reinforce stereotypes (Anderson et al. 2004; Anderson and Carnagey 2009; Granic, Lobel, and Engels 2014; Greitemeyer and Mügge 2014). Designing games to be collaborative rather than competitive, limiting the exposure time, and infusing positive messages for social inclusion can prevent such behaviors and maximize the potential benefits of videogames (Gee 2005; Kirkley and Kirkley 2005; Mateo Dias and Becerra 2019). Videogames can also equip children and youth with teamwork, communication, creativity, problem-solving, and solidarity skills (Schmierbach 2010; Ferguson and Garza 2011; Granic, Lobel, and Engels 2014; Kelly and Nardi 2014). Several programs in LAC try to make the most of these positive aspects of videogames. [6]

5• The study was limited to evidence from randomized evaluations and regression discontinuity designs.
6• Widely used videogames include Creápolis (Argentina), Qranio (Brazil), Kokori (Chile), Shamanimals Fantastic Tales (Colombia), Local Heroes (Mexico), and DragonBox (Uruguay). They focus on school desertion, the teaching of traditional content, and the development of nontraditional skills (see Mateo Dias and Becerra 2019).

Technology and Inequality

Incorporating technology and 21st century skills to education and learning processes also provides an opportunity to tackle inequality. In an unequal environment, where the education of parents can determine the academic future and career opportunities of their children, and in a context in which almost half of students in the region do not complete secondary school, improving the quality of education and training systems is essential to render them more relevant and flexible, so that children and youth are given the opportunity to break with that legacy. No 21st century society can afford to have low-skilled citizens. In a world in which such people will be displaced by automation and human skills will mark the difference, equipping citizens of all ages with the needed foundational skills should be at the core of any human capital formation system.

Technology can help. A good example is the distance learning model of Mexico implemented using televised sessions (telesecundarias) to expand secondary education to some 1.4 million children in remote rural areas that lack qualified teachers. Two studies assessing the impact of the program on labor market returns show that it increased enrollment, graduation rates, and further schooling and yielded significant increases in labor force participation and average income for beneficiaries (Fabregas 2017; Navarro-Sola 2019).

When we think of inequality and the digital divide, we usually refer to the socioeconomic gradients in access to technology (Campbell 2001)[7] and the differences in the resources and capabilities to effectively use ICT (Georgiadou 2017; Marcelle 2000; Vrasidas, Zembylas, and Glass 2009). We think, for example, of tablets, laptops, robots, or interactive platforms with which children learn new (e.g., coding) or traditional (e.g., mathematics) skills better or faster. Students from higher-income backgrounds have the greatest access to and consume more of these types of resources.

But the digital divide is not just about the availability of technological infrastructure. It is also about how teachers and students engage with those resources in the classroom. For example, some evidence suggests that the use of ICT in hard-to-staff schools in low-income neighborhoods tends to be limited to drill and practice routines, whereas access to ICT by high-income students is linked to critical and creative activities (Vrasidas, Zembylas, and Glass 2009).

Another way to read the digital divide, as technology becomes cheaper and more widespread, is to think of it as a cheaper way to access educational services. Learning through technology is no longer a privilege; it can actually turn into a disadvantage. To illustrate this point, an article in the New York Times (Beckerman 2018) started with this:

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[7] The socioeconomic gradient in access to technology refers to the fact that inequalities in access to technology are related to inequalities in socioeconomic status. Within countries, the lower an individual's socioeconomic status, the less access he or she generally has to technology.
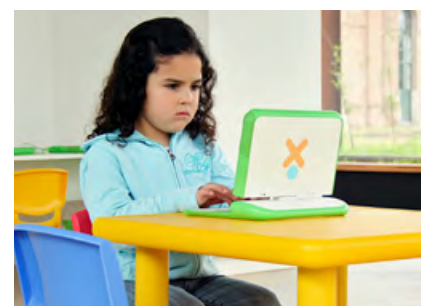
Hypocrisy thrives at the Waldorf School of the Peninsula in the heart of Silicon Valley. This is where Google executives send their children to learn how to knit, write with chalk on blackboards, practice new words by playing catch with a beanbag and fractions by cutting up quesadillas and apples. There are no screens—not a single piece of interactive, multimedia, educational content. The kids don't even take standardized tests.

The activities for the wealthy students at the Waldorf School underline the importance of analogue experience, which is foundational and critical to the development of other skills. Countries around the world, including in LAC, are investing more and more in technological equipment and digital resources to close the skills gap in the labor market (Flores and Melguizo 2018) and the learning gap between high- and low-income students (Arias Ortiz, Bornacelly, and Jaureguiberry 2018). Without careful consideration of its application in the classroom and the skills it tries to nurture, technology could potentially increase rather than decrease inequality in skills and learning.

What are the lessons that matter most? Good jobs require a combination of technical and soft skills. They always have. What is changing is the distribution of the two types of skills (Einav and Levin 2017). Although cognitive skills are still strongly related to labor market participation and income, their importance has been falling over the last two decades while the returns to soft skills have increased, in countries such as the United States. This trend is not accidental: To survive in the world of automation, people must be able to do what machines cannot (Ma 2018), because jobs that require imagination, creativity, and strategy are more difficult to automate (Pistrui 2018).

An interesting fact comes from a study conducted by Google in 2013 to understand whether its recruitment strategy focused on hard skills in computer science was appropriate (Strauss 2017). The results revealed that seven of the eight most important qualities shared by the highest-performing employees were soft skills, such as being a good coach; communicating and listening well; knowing one's colleagues well; being empathetic; and being good at critical thinking, problem solving, and connecting complex ideas. Technical competence in science, technology, engineering, and math (STEM) came in last.

There are limits to what technology can do. Learning to knit, write with chalk, or practice new words while playing with balls can be part of a strategy to innovate; education systems need to be careful to ensure a good balance. As the New York Times article noted:

> While Silicon Valley's raison d'être is to create platforms, applications and algorithms to generate maximum efficiency in life and work (a "frictionless" world, as Bill Gates once put it), when it comes to their own families (and also developing their own businesses), the new masters of the universe have a different sense of what it takes to learn and to innovate: it is a slow and indirect process, it is necessary to meander, not run, allow failure and chance, even boredom.

Structure of the Book

This volume charts five stories in which countries successfully integrated technology into their production functions and transformed their education systems, significantly improving learning outcomes. It is divided into four parts:

Introduces the case of Finland, where the government aligned their education system with the country's socioeconomic strategy.

Analyzes how the governments of Korea and Uruguay designed and implemented unique institutional strategies to implement and integrate technology into education.

Explores how education systems can better respond to skill shifts in the labor market. The case on Estonia shows how government emphasized digital skills of all citizens. The case on the United States shows how technology can provide new ways of learning traditional subjects and add content, such as computational thinking, that had not previously been integrated into the curriculum.
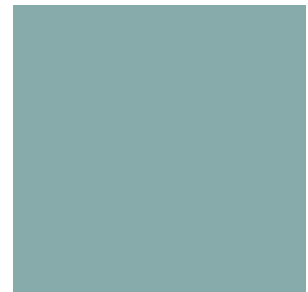
Compares countries' efforts and reforms to respond to the rapid changes in society, integrate technology into education, and provide quality education for all. It provides a checklist of the critical issues reformers will encounter and identifies the main tradeoffs for policymakers introducing new technologies into the classroom.

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Chapter 2

Marjo Kyllönen

Smart Learning and the School of the Future: Finland

Marjo Kyllönen

Finland is perceived as one of most innovative countries in the world (Bloomberg 2019; Dutta, Lanvin, and Wunsch-Vincent 2018). Its unique education system is one of the country's cornerstones. The high value placed on education in Finnish society is evident in both policy and the way the private sector emphasizes its value. Good-quality education is one of the key success factors behind the country's economic growth and competitiveness. It is a seedbed for Finland's societal and economic success (OECD 2005; Havgreaves, Halasz, and Pont 2008; Simola 2017).

Globalization tends to accelerate polarization, increasing the gap between rich and poor countries as well between rich and poor individuals within countries. In the battle against poverty, offering equal opportunities for every child to access good-quality education is crucial. Education also plays a central role in ensuring civic literacy and the acquisition of the skills needed for future society and the labor market.

This chapter examines the role of education in society. It is organized as follows. The first section addresses the key elements in the Finnish education system and reviews the history of educational reform in Finland since the 1970s. The second section makes the case for the urgent need to rebuild the education system to prepare for the future. The third section defines the key elements of smart learning and the school of the future, the cornerstones of digital learning. The fourth section takes up the question of sustainable change. The last section summarizes the chapter's conclusions and draws some policy implications.

The Finnish Success Story

Schools play a central role in promoting social, emotional, and physical well-being, especially among the less privileged. Socioeconomic background is one of the strongest factors shaping a child's future. Good-quality education can reduce the effect of social background and increase equality and equity (Dalin and Rust 1996; OECD 2016).

Finland considers public education a key instrument for social mobility and personal development and well-being. Raising the level of education has had a direct impact on the rise in labor productivity and Finland's rapid economic and social development (Asplund 1999). Figure 2.1 shows economic growth in Finland between 1970 and 2017. It is positively correlated with both enrollment in compulsory education (shown in figure 2.2) and enrollment following completion of compulsory education (shown in figure 2.4).

Figure 2.1 Per capita gross domestic product in Finland, 1970–2017

Per capita GDP
(current US dollars)
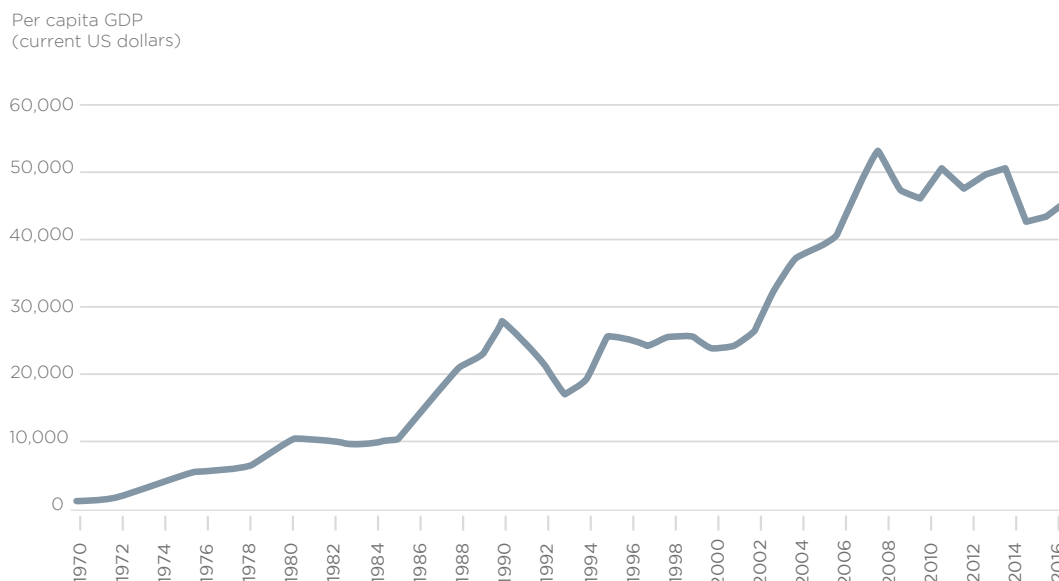
Source: World DataBank.

By global standards, Finland's educational achievements are astonishing. For more than 10 years, Finland has ranked among the world's top performers on the Programme for International Student Assessment (PISA). Finland's educational system has also managed to avoid some of the trends that dominate education in Western countries (Sahlberg 2007; Kupiainen, Hautamaki, and Karjalainen 2009; Lonka 2018) (table 2.1).

Table 2.1 Differences between Western and Finnish models of education

Western model	Finnish model
Standardization Strict standards for schools, teachers, and students, to guarantee quality of outcome	**Flexibility and diversity** School-based curriculum development, steering by information and support
Emphasis on literacy and numeracy Basic skills in reading, mathematics, and science as prime targets of education reform	**Emphasis on broad knowledge** Equal value to all aspects of individual growth and learning (personality, morality, creativity, knowledge, and skills)
Consequential accountability Evaluation by inspection	**Trust trough professionalism** Culture of trust of teachers' and headmasters' professionalism in judging what is best for students

Source: Kupiainen, Hautamaki, and Karjalainen 2009.

Characteristics of the System

Several features characterize Finland's system. First, education is highly valued and built on trust, the core value in Finnish society. Parents and society trust schools and teachers, principals trust their personnel, and so on (OECD 2005).

Second, Finland values the autonomy of its schools and teachers. The system is flexible, diverse, and decentralized—decision-making happens at the local level. The country does not rank or inspect schools. Quality is assessed based on self-evaluation, surveys of customers (parents and students), and coaching (Sahlberg 2007; Kupiainen, Hautamaki, and Karjalainen 2009).

Third, Finland emphasizes the holistic growth and well-being of its children. Much effort is put into individual tutoring and supporting everyone's learning. The focus is on providing learners with a broad concept of knowledge that values equally all aspects of individual growth, including the social-emotional and ethical dimensions (Sahlberg 2007; Kupiainen, Hautamaki, and Karjalainen 2009).

Fourth, Finnish teachers are highly educated and strongly committed to their work. In comprehensive and upper-secondary general education, all teachers are required to have a master's degree. Teaching and guidance staff at day-care centers generally have bachelor's degrees. Pre–primary school teachers are required to have at least a bachelor's degree (some hold master's degrees). The high level of teacher qualifications is a key factor of success. It is also a necessity, as Finnish schools and teachers are very autonomous (OECD 2005; Lonka 2018).

Fifth, Finland has a two-tiered institutional design, in which the Ministry of Education and Culture is in charge of legislation and budgeting and the Finnish National Agency for Education is in charge of the implementing education policies. This structure allows for education to transcend the political commitment of a particular administration. It sets the vision, designs the curriculum, and plans and executes policies over the long term. Sixth, education in Finland is free of charge from pre-primary to higher education, and most children attend neighborhood schools. Geographical segregation is much lower than in the United States or in other European countries (Bernelius 2013).

Uno Cygnaeus (1810–88) introduced the idea of public education for boys and girls in Finland the 1850s. The first act requiring local authorities to provide basic education for all was passed in 1868. However, it was not until 1921 that attending basic education was made compulsory for school-age children (Lonka 2018). In 1920, about 70 percent of 15-year-olds in Finland were literate. By the mid-1930s, about 90 percent of 7- to 15-year-olds received schooling. Gradually, education reached all children. By 2015, the enrollment rate for compulsory education was virtually 100 percent (figure 2.2).

Figure 2.2 Enrollment rate for compulsory education in Finland, 1920–2015

Enrollment rate (percent)
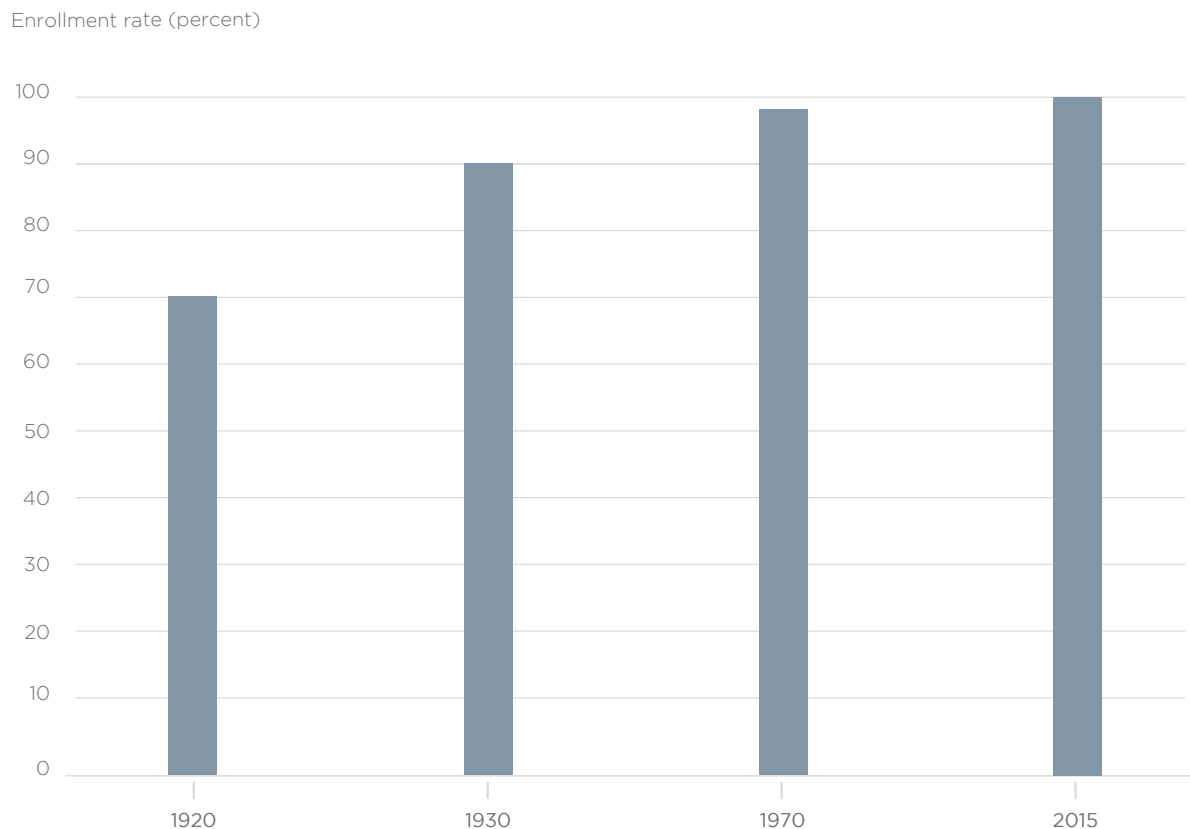
Source: Statistics Finland 2019.

Note: The figure for 1920 indicates the percentage of students who were literate, not the percentage enrolled in school.

Finland is considered one of the equal countries in the Organisation for Economic Co-operation and Development (OECD). The learning gap between the highest- and lowest-performing students is the smallest in the OECD. Differences between Finnish schools are minimal (OECD 2016).

Some signals raise concerns about growing inequality in education, however, as the influence of the socioeconomic background on learning outcomes has increased. Students from immigrant background perform worse than other students, and the gender learning gap has grown slightly (in favor of girls) (Bernelius 2013; OECD 2016).

One indicator of equity is the dropout rate, which is very low. Although it rose slightly in the past few years, 99.5 percent of Finns complete compulsory education (table 2.2).

Table 2.2 Comprehensive school dropouts in Finland, 1999/2000–2016/17

Academic year	Number of students who dropped out of compulsory education[a]	Number of students who left compulsory education without a certificate[b]	Percent of all ninth grade students who left compulsory education without a certificate[b]	Number of ninth graders in spring term
1999/2000	90	193	0.29	66,821
2000/01	69	210	0.33	64,512
2001/02	63	191	0.31	62,095
2002/03	79	161	0.26	61,419
2003/04	67	178	0.28	64,456
2004/05	70	218	0.34	64,350
2005/06	60	178	0.27	66,473
2006/07	55	152	0.23	66,230
2007/08	47	117	0.17	67,388
2008/09	39	150	0.23	65,687
2009/10	41	152	0.23	65,560
2010/11	95	180	0.28	64,125
2011/12	86	212	0.34	61,778
2012/13	85	202	0.33	60,323
2013/14	78	269	0.46	58,555
2014/15	71	301	0.51	58,919
2015/16	94	315	0.54	58,707
2016/17	73	314	0.54	58,376

Note:

a. Children of compulsory education age who did not take part at all in comprehensive school education during the 2010/11 academic year during the spring term are regarded as having dropped out of compulsory education. Data starting in 2010/11 are not fully comparable with earlier years.

b. People who left comprehensive school without a certificate are people who are past the compulsory age of compulsory education who did not complete the whole compulsory school syllabus during their compulsory education.

Source: Statistics Finland 2019.

History of Reform

Phase I: Replacing the parallel system of grammar and civic (vocational) schools in a drive to increase equity

The Finnish concept of comprehensive education for all was built on a vision of equality and equity that emerged in the 1970s, when the educational system underwent fundamental reform. The leaders of the effort understood that for Finland to be successful in the future, it could not squander any potential. There was a strong consensus among decision makers that a comprehensive education was needed to achieve economic growth and competitiveness. The vision sought to offer equal opportunities to every child, irrespective of background, by replacing the parallel system of grammar and civic (vocational) schools with a single system of comprehension education (Kupiainen, Hautamaki, and Karjalainen 2008; Lonka 2018.)

Before reform, the system drove Finland toward more rather than less inequality. All children received four years of elementary education. After that, students could apply to grammar school or remain in a civic school, which led to vocational professions. Grammar school was the path to high school education and after that to university. Most grammar schools were private and charged school fees.

In the 1960s, 60 percent of students received civic school education, which meant that more than half of secondary students could not apply for high school. In 1970s, the situation changed a bit, but even then only 60 percent of students attended grammar school, the only path to higher education (figure 2.3).

Figure 2.3 Enrollment rates for civic (vocational), grammar, and high school in Finland, 1950–70

Enrollment rate (percent)

Source: Statistics Finland 2019.   1950   1960   1970
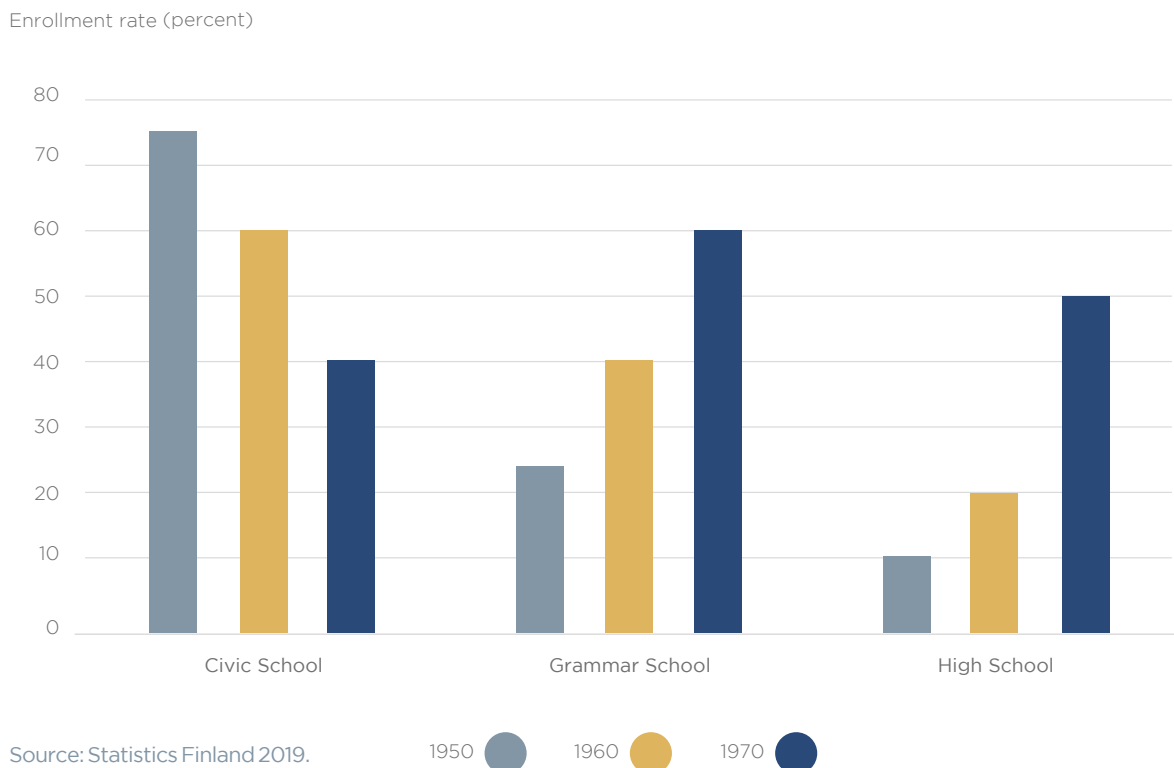
The new concept replaced the parallel system of grammar and civic (vocational) schools with a comprehensive school from first to ninth grade. Students with different competencies, social or economic backgrounds, and needs of support sat in the same classroom, taught by the same teacher. The act for basic education was adopted in 1968; application of it started in 1972, first in northern Finland and then in southern Finland, until it was fully implemented by 1977 (Kupiainen, Hautamaki, and Karjalainen 2008; Ministry of Education and Culture 2017; Lonka 2018).

What Finland did was more than just have all children from the neighborhood sit in the same classroom. It adopted a revolutionary approach to learning—a new mindset, a changed attitude, a new culture—that recognized the importance of educating the whole population. Reform represented value-based action toward equity.

To give teachers the new tools they needed to support all learners in achieving their potential, Finland launched large-scale in-service training (Kupiainen, Hautamaki, and Karjalainen 2008). The impact of the effort is evident in the increase in the share of adults 25–34 with middle (upper secondary or vocational) or higher (tertiary) education (figure 2.4).

Figure 2.4 Percentage of students in Finland who continue school following completion of basic education, 1975–2005

Year	Middle or higher education	No degree after basic education
1975	50	50
1980	62	38
1985	73	27
1990	80	20
1995	82	18
2000	83	17
2005	85	15

Middle or higher education ⬤   No degree after basic education ▨
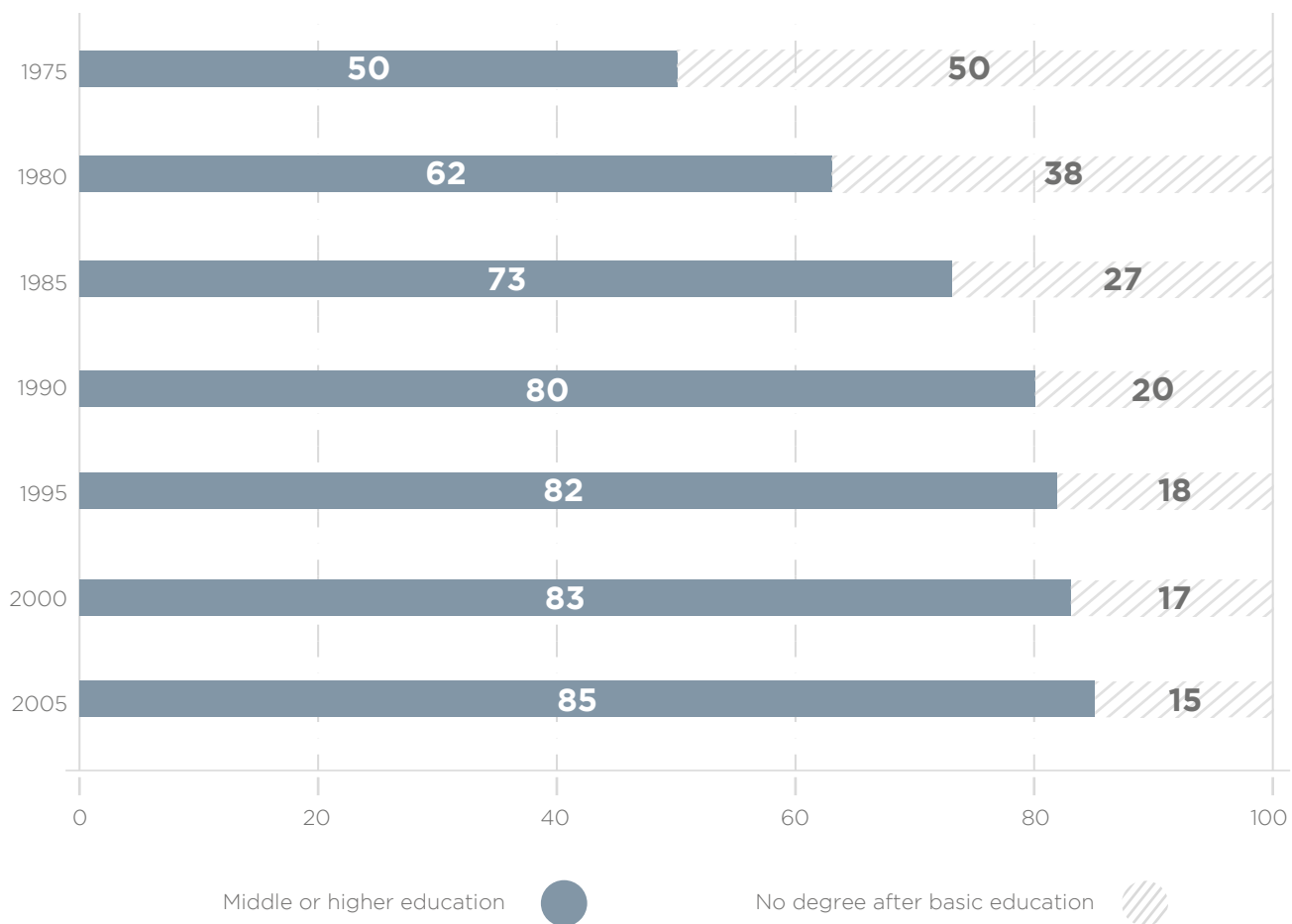
Source: Statistics Finland 2019.

In the 1960s and 1970s, before school reform was implemented, many Finnish families recognized the importance of higher education as a ladder to a better life. But few students had the opportunity to access it (figure 2.5). Between 1975 and 1980, the number of students receiving higher education soared.

Figure 2.5 Gross tertiary enrollment rate in Finland, 1971–80

Gross enrollment
rate (percent)
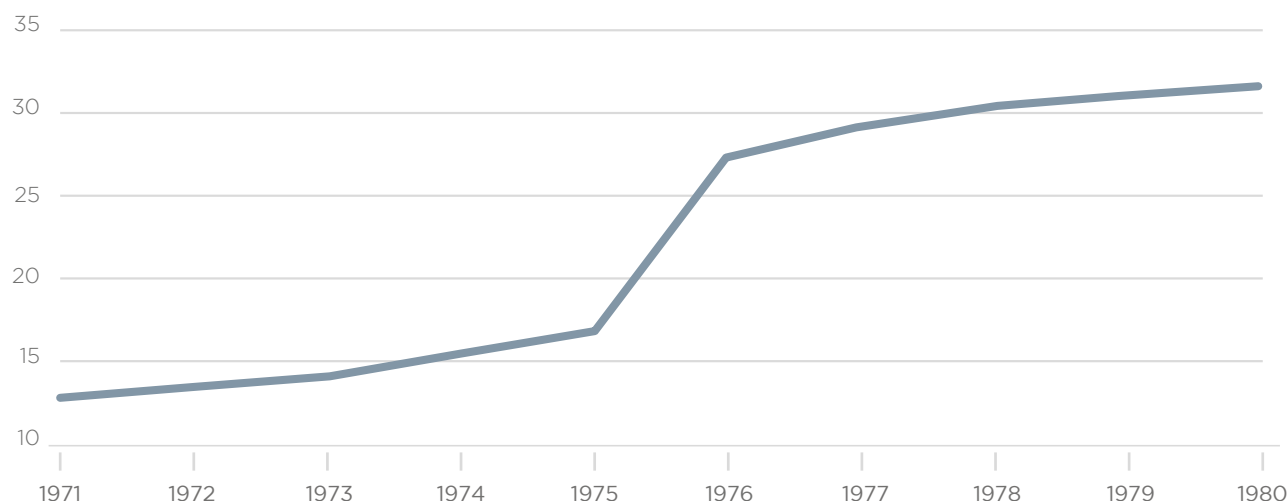
Source: World DataBank.

Phase II: Preparing for the information society

In the mid-1990s, the Finnish government launched a comprehensive national strategy for the information society. The model combined a highly competitive knowledge-intensive economy with an inclusive welfare model (Castells and Himanen 2002).

In 1995, the Ministry of Education introduced a program for information and communications technology (ICT)–based learning. The use of ICT in learning and teaching was considered key to accelerating success (Ministry of Education 1995; Ministry of Finance 1996). Education was to play a central role in promoting new skills needed in the information society. The main objectives were as follows:

- Provide all boys and girls in primary and secondary schools with ICT skills.

- Ensure that teachers have high-quality content knowledge and the pedagogical skills to supervise learners in independent inquiry.

- Train teachers to use different media in teaching and to develop relevant learning materials for these environments.

- Offer pre-service and in-service teacher education to meet the new requirements.

- Establish safe and well-functioning infrastructure and ensure sufficient numbers of ICT devices (Ministry of Education 1995).

Training for teachers and principals was launched across the country. Every local authority and all schools wrote their own ICT strategies. In 1999 the Ministry of Education updated its ICT strategy. It consists of the following development projects:

- Information skills for all

- The Teacher.fi project (Ope.fi) [8]

- In-service training for professionals

- The virtual school concept and digital learning materials

- Research in learning environments (Ministry of Education 1999).

Many of these projects had strong connections to initial and in-service teacher training. The objective of the Teacher.fi project was for all teachers to achieve the minimum level of ICT skills in 2000–04. ICT was an integral part of the education and learning process, not a separate component. At its best, the ICT strategy helped the whole school develop as a community.

Earlier, ICT has been more of a technical tool, something that simply replaced pen and paper. Under the reform, it now has its own value— as a pedagogical tool whose value is measured by how much it adds to the quality of learning and the promotion of collaboration and participation (Niemi 2003). This approach was also adapted in the national curriculum reform that took place in 2003/04 and implemented locally in 2006.

[8] • Ope.fi is a Finnish website for sharing good pedagogical practices. It offers teachers practical tools for implementing new pedagogical approaches.

Why Is a New School Design Needed?

All of these reforms were needed and successful. They set Finland's education system and its practices in the right direction. However, what was helpful in the past is not necessarily relevant for the future. To build a successful future, policymakers may have to rethink practices and rewrite the narrative for schools, because the change in the environment is challenging the current school and its structures. Finland—like the rest of the world—is living in an era of accelerating change. Predicting the future is more difficult than it once was.

To address the drivers of change, we need to embark on a social transformation that affects learning and education (Dalin and Rust 1996; KnowledgeWorks Forecast 4.0 2015). The current school was designed for the needs of the industrial era, a time of mass production and specific professions. Obedience alone was a reasonable competence at the time of spinning jenny technology. This world no longer exists, but the design of the average school in Finland has remained almost unchanged. The school system still adopts the modes and functions used a generation ago. It does not reflect the new demands and expectations of life in the 21st century.

Technology has historically been one of the drivers of education systems. New technology has changed the way people act, think, communicate, and socialize. It has an enormous impact on everyday life.

The traditional school concept was built in a world where a teacher was the gatekeeper of information. Today information is everywhere, accessible to everyone. Information is not only accessible, anyone can modify it; anyone can be not only a consumer but also a producer of information.

Digitalization—the use of new algorithms and artificial intelligence—provides many untapped possibilities for learners. Artificial intelligence can replace the decision of humans, allocating resources in the most effective way to meet individual learners' needs, for example. It allows learners to connect to other leaners through a multidimensional and flexible network. Algorithms can also replace administrative work (Bauman 2000; KnowledgeWorks Forecast 4.0 2015).

Is the world ready for these changes? What will happen if artificial intelligence replaces most of the traditional distribution of knowledge done by teachers?

Rapid and turbulent change is challenging teaching methods and traditional school models. In the future, society will be more knowledge intensive than ever. Countries need to equip their children with the competences they will need; to promote holistic competences and knowledge; and to develop and nurture skills such as critical thinking, collaboration, cultural sensitivity, and social

responsibility. Capacities like creativity and complex problem solving are now critical. Teaching and testing routine skills is no longer relevant, as machines will handle most of the routine and part of the nonroutine work. More flexible and customized models will replace the traditional way of teaching and learning. Formal education will be more fluid, as networked structures and education services are offered in ways that meet the needs of local neighborhoods. Optimizing and customizing learning paths for learners and at the same time cultivating collaborative work will lead to new learning innovations (Bauman 2000). But there is also the possibility that highly motivated children will have a huge advantage over others and that their less fortune classmates may drop out (Brynjolfsson and McAfee 2014; OECD 2016.)

What is worth learning, and how should it be learned? Does the current education system prepare children for society and the labor market? Are children gaining the competencies they will need to succeed in the future? How can learning be made more meaningful for children?

The traditional way of teaching fragmented pieces of knowledge is no longer relevant. Learning must make sense to children. They must understand why and for what purpose they are learning and how to use the competencies and skills they acquire in everyday life. To do so, they must move from repeating or just searching for information to understanding and valuing it (Dalin and Rust 1996; KnowledgeWorks Forecast 4.0 2015; Salmela-Aro et al. 2016).

Smart Learning, Technology, and 21st Century Skills

Smart learning is a pedagogical transformation. It does not simply replace traditional books and pencils with technology; it embraces a new pedagogical approach and understanding.

Educational systems must reflect the societies in which their people would like to live in 20 or 30 years (Dalin and Rust 1996). The future of society lays in the hands of its schools and educators. Choices made today determine the future course.

Children who now are beginning their school career will be in the labor market in 2070. Given the changes that are likely to take place over the next several decades, learning to be competent in one profession is not sufficient. In this complex, multidimensional world, schools need to provide children with resilience, motivation, and competence to learn. Schools must develop flexible minds, understanding, and respect for every member of society, regardless of background or capabilities (Adler 2002).

Finland's latest curriculum reform was in 2014, when the new guidelines for national core curriculum for pre-primary and basic education were adopted. The focus of the new curricula was on holistic competencies and 21st century skills. Instead of learning content (what to know), the new curricula emphasize the learning process (how to learn). This flip was essential. Learners no need to master specific subjects. Life is not split into subjects—why should learning? Cross-disciplinary thinking and the ability to approach a problem using tools from various subject areas are needed. These skills cannot be taught if the learning process is split into isolated subjects. (Finnish National Board of Education 2016).

Helsinki educators want to create the world's most impactful places to learn. The entire city is used as a place for learning for people of all ages. Learning happens everywhere, and all places are learning places. Learning is seen as a flexible, open, and collaborative process. Digital technology enrichens the learning process and enables learning regardless of time and place (Helsinki City Strategy 2017–21). Figure 2.6. Illustrates the pathway to smart learning.

Figure 2.6 Key elements of smart learning

Smart Learning
Building the Future with Technology

- ePortfolio as a tool for learning and evaluation (data analytics)
- Vision and concept
- Whole city as an urban learning environment
- Developing smart learning environments for deep learning for 21st Century skills
- Internet of things
- Phenomenal learning Adaptive learning
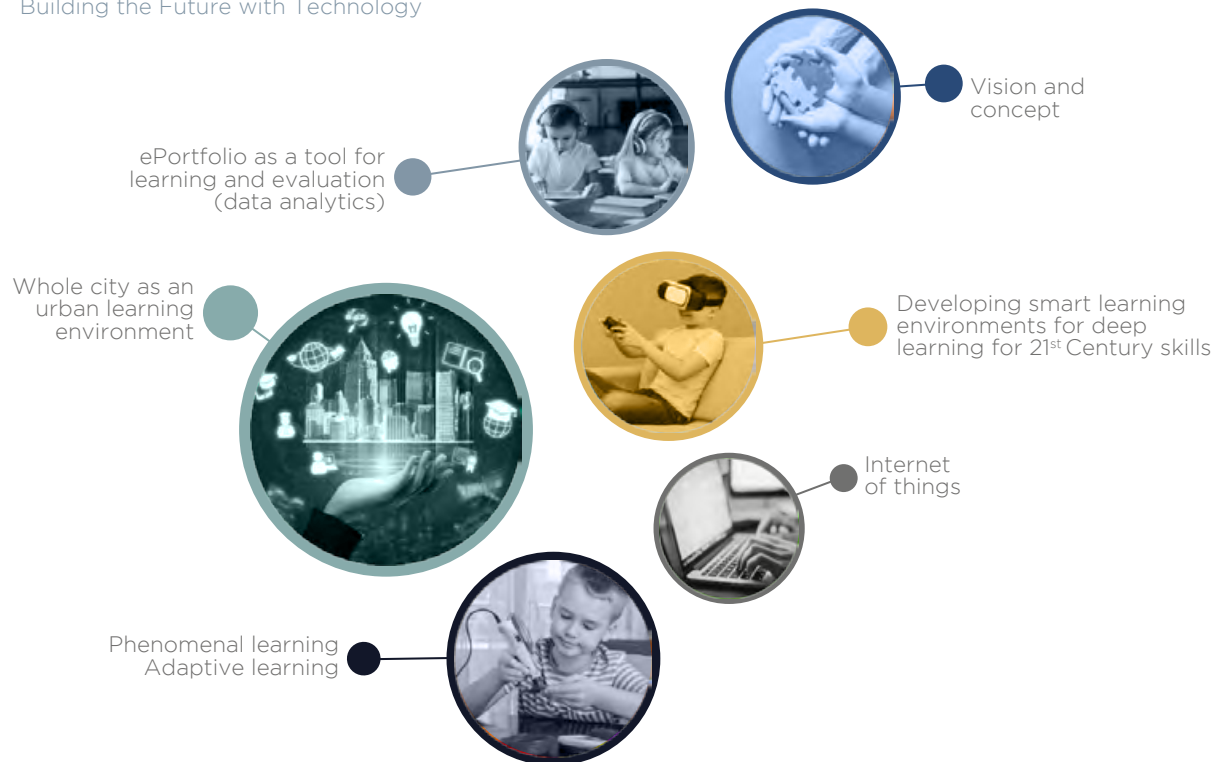
Source: Helsinki City Strategy 2017–2021.

The key to successful and sustainable change is pedagogy. Finland has adopted a new narrative for learning in which the focus is on honing meaningful learning and holistic competencies, anchoring learning in real-life phenomena, and fostering creativity and critical thinking. Digitalization offers new possibilities to customize and individualize learning paths, fostering adaptive learning that promote everyone's potentials. Educators also understand the importance of collaboration, co-creation, and social and emotional skills. They therefore emphasize the importance of doing things and constructing knowledge together with other learners (OECD 2016; Kyllönen 2018; Lonka 2018).

The new approach to learning is flipping the traditional setting in the classroom, in which the teacher used to be in control of the learning process. It promotes student participation and gives students an active role in learning, empowering students. The role of the teacher is to scaffold[9] the learning process and help make the objectives visible to learners. Learning becomes fun and motivating when students see that what they learn is connected to their real lives and recognize that they can affect the quality of their own learning (Kyllönen 2018; Lonka 2018.)

One very effective and practical tool for achieving this flip is phenomenal learning, a holistic approach in which learning is meaningful and related to children's everyday life. The focus is on the learning process instead of the end product. The role of the student is active, from planning to assessment.

Finland wants to promote smart learning, smart well-being, and a smart environment. To do so, it includes robotics and coding as part of the curriculum, in order to promote computational thinking. In order to avoid simply replacing books and exercises with digital platforms—which at their worst promote platforms for repetition and mechanic learning—educators ask themselves whether a digital solution or device brings added value to the learning process and reflects their pedagogy and vision (Finnish National Board of Education 2016).

The new approach has already shown itself to be motivating, fun, and deep. As one 11-year-old student said, "This new curriculum is so cool—we have an active role, we do things together and learn together—and better."

9• Instructional scaffolding is support given during the learning process that is tailored to the needs of the student and helps the student achieve his or her learning goals. This learning process is designed to promote a deeper level of learning. Teachers help students master a task or a concept by providing support such as outlines, recommended documents, storyboards, or key questions.

Effecting Sustainable Systemic Change

A holistic approach is needed to achieve sustainable systemic change. Systemic thinking helps educators understand that everything happens in a context, to view the whole pattern and lead the organization in the direction of meaningful change (Dalin 1998).

Why it is so difficult to change schools and pedagogical practices? Every organization has its unseen or unrecognized basic assumptions; many believe that the way they have always done things is the way they should do things in the future (Schein 1985). These basic assumptions can sustain an organization, but they can be very dangerous if an organization keeps on engaging in business as usual even if the pattern is no longer relevant.

Members of schools (teachers, principal, support staff) and schools' customers (parents, students, society in general) all grew up with schools. They have a clear picture of what a school and classroom look like and how a school functions. The problem is that the world has changed; what was relevant in the past no longer meets the needs of today's and tomorrow's society (Kyllönen 2018).

Rewriting the narrative for the future school requires a deep understanding of systemic change and how to make it happen. Sustainable change requires an understanding of the school as an organization—its structure, leadership, culture, and implementation of pedagogy, all of which must be developed in a systemic and holistic process (figure 2.7).

Figure 2.7 The smart learning model of sustainable, systemic, and holistic change
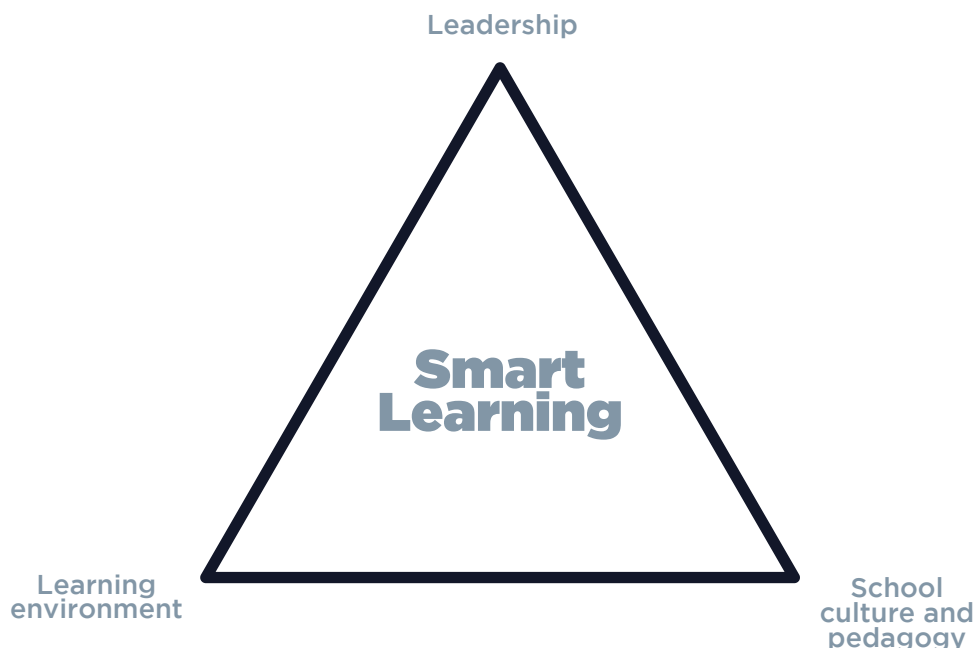
Source: Kyllönen 2018.

The most important factor is the quality of leadership and how leadership is used. Talented leaders empower the whole community, providing vision and hope. They see the possibilities and recourses they have and are able to elevate people to another level. They value every member of the organization and understand that best results are achieved when people participate in and belong to the society (Ganz 2011; Kyllönen 2018.) They achieve results not by telling people what to do but by calling on them for collaboration and co-creation.

Not even the best leader can make this transformation alone. The organizational culture is critical. If it is resistant, sustainable change cannot happen. Leaders create the conditions for the growth of the school operational culture, and the culture of the school organization fosters good leadership practices (Fullan 2005). If leadership fails, the organization cannot succeed.

Change must happen at all levels. If, for example, a goal is for students to work together to solve problems, teachers must do so first. Learning that is collaborative, cross-disciplinary, and related to real-life challenges teachers to plan, work, and evaluate together. Not only teachers but the whole community—from schools to neighborhoods—must be involved and empowered.

The school organizational culture plays a crucial role in forming attitudes and pedagogical approaches (Schein 1985). The pedagogical environment comprises the approaches, techniques, and tools a system designs and implements for learning. It is a mindset—the teacher's perception of good learning. Designing a good-quality pedagogical learning environment requires deep understanding of smart learning and the competencies required to implement its principles. A good social and emotional environment promotes well-being, a sense of belongingness, safety and collaboration at every level.

Physical and virtual environments are equally important; how they are designed and used matters. The design of learning spaces must reflect the pedagogy applied. Figure 2.8 illustrates the elements of a successful learning environment.

Figure 2.8 Elements of a successful learning environment and school culture

Source: Kyllönen 2011.

Conclusion and Policy Implications

For a country to be successful in the future, it must invest in good-quality education. Such an education has a direct impact not only on the quality of an individual's life and well-being but also on the economic growth and competitiveness of the country. Education should promote social cohesion, a key element for the success of a society and economy. Social exclusion and polarization create tensions and challenges that are not beneficial for individuals, society, or business—particularly today, as globalization and digitalization tend to increase polarization both between and within countries.

Success in education requires holistic, systemic change. It must happen at all levels of the organization, in a way that empowers all stakeholders. If people are not empowered, change will remain superficial.

Digitalization is all about the transformation of pedagogical approaches and practices. Technology can have a major impact on individuals' as well societies' learning processes, by accelerating deep learning and helping learners achieve holistic competencies. But not all applications and digital platforms or tools are beneficial. Before creating a digital and virtual learning environment and platforms, leaders must be certain that the technology enhances the learning process.

Sufficient freedom for decision-making must be granted at the local level. If the system is very centralized, teachers and principals cannot perform their best and give the best to their students. A centralized decision is almost always an average solution.

Giving the best to children requires mutual trust and valuation. It also requires a willingness to break from the traditional ways of doing things, to try something that has not been done before. If Henry Ford had asked people what they wanted, they probably would have said faster horses. Innovators must ask "Do the solutions of today limit the ability to see the needs and possibilities or tomorrow?"

The school of the future should be a place of fun, where students are motivated to learn and learning is meaningful. It should be a place where children can explore their world with enthusiasm and learn exciting lessons they will never forget.

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PART
02

Changing
Institutions

Chapter 3

Changha Lee

Aligning Education with a National Vision: Korea

Changha Lee

This chapter sheds light on how the Republic of Korea created a strong information technology (IT) economy and the role that education played in catapulting it to the top of many indexes (box 3.1). The first section describes Korea's development strategy of linking economic development with education policies. The second section examines Korea's vision for information and communications technology (ICT) education. It shows how the Korean government approached the rise of the Fourth Industrial Revolution, established a national vision toward ICT education, and implemented policies through a quasi-governmental institution to prepare for the next generation accordingly. Section three describes the establishment of the Korea Education and Research Information Service (KERIS). Section four reviews the country's five ICT master plans for education. The last two sections summarize lessons learned from Korea's experiences in Korea and discuss remaining challenges.

Box 3.1

Korea's achievements in innovation and human capital

Korea is considered one of the world's most technologically advanced countries. Between 2010 and 2017, it ranked first or second on the International Telecommunication Union's ICT Development Index on access to information technology (IT) infrastructure, use of Internet, and education level of the public necessary to support the expansion of technology.

Korea's economy was rated the world's most innovative economy in 2018, ranking first on the Bloomberg Innovation Index (BII) for the fifth consecutive year.[10] It scored in the top five for most criteria (criteria include education, research and development spending, patent activity, and the concentration of high-tech companies). It ranked first in patent activity, based on the patents acquired by Samsung, the country's most valuable company by market capitalization. It awarded more U.S. patents in the first decade of the 21st century than any firm in the world except IBM.[11] Korea is also home to other international corporations, such as LG and Hyundai, the world's fifth-largest automaker.

One of the main explanations for Korea's success is its robust human capital. In 2018, Korea ranked second in the world (after Singapore) on the World Bank's Human Capital Index, which measures the amount of human capital a child born today can expect to attain by age 18.[12] Students in Korea ranked first on ICT literacy skills, defined as the "ability to use and create technology-based content, including finding and sharing information, answering questions, interacting with other people, and computer programming" (WEF 2015, p. 23). In 2012, Korean students scored in the top three in both digital reading and mathematics on the Program for International Student Assessment (PISA) (OECD 2015).

10• https://www.bloomberg.com/news/articles/2018-01-22/south-korea-tops-global-innovation-ranking-again-as-u-s-falls
11• https://www.bloomberg.com/news/articles/2018-01-22/south-korea-tops-global-innovation-ranking-again-as-u-s-falls
12• https://www.worldbank.org/en/data/interactive/2018/10/18/human-capital-index-and-components-2018

Korea's Development Strategy

The astonishing IT economy that Korea built is only half a century old. In the 1960s, Korea was one of the poorest countries in the world, with annual per capita income of just $160; by 1995 it was the 12th largest economy in the world, with annual per capita income of $12,300 (Campbell 2012; World DataBank 2019). In 2009, Korea became a member of Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD), a forum of the world's major donor countries. It is the only country that moved from recipient to donor.

Researchers have concluded that far-sighted, state-directed, long-term plans that carefully aligned economic development with education policies accounted for Korea's unprecedented development (Chung 2007; Campbell 2012; Hultberg, Calonge, and Kim 2017). As Fleckenstein and Lee (2018, p. 1) note, "Education policy, as part of centrally orchestrated industrial policy, played a key role in the rapid economic development of the country."

Korea went through four development phases: light, labor-intensive manufacturing; heavy chemicals; high-tech electronics; and IT. Each phase was preceded by an expansion of education, revealing the careful linking of economic development with education policies in the second half of the 20th century (figure 3.1). The investment and expansion of primary education in the 1950s created an abundance of cheap labor and allowed Korea to debut in the global market with light and labor-intensive manufacturing in the 1960s. Korea achieved universal primary education in the early 1960s. In the 1970s, it allocated resources to rapidly expanding secondary education; heavy industry was able to draw on the influx of high school graduates. In the 1980s, when Korea began to transition into electronics, the country called for better educated workers. To meet the demand, university enrollments mushroomed.

Figure 3.1 Primary, secondary, and tertiary enrollment rates in the Republic of Korea, 1950–2015

Enrollment rate (percent)
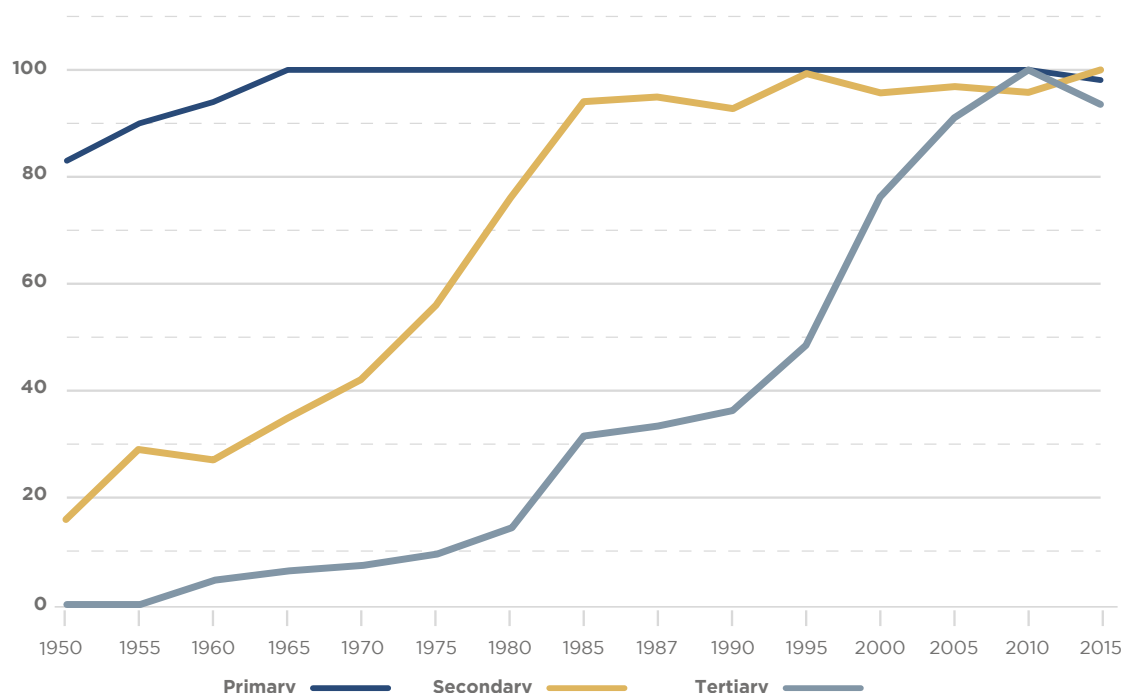
Source: Data from Adams 2010 and World DataBank.

The Vision for Information and Communication Technology Education in Korea

In the 1990s, Korea took advantage of the increased quality of labor and began to thrive in the electronic industry. The share of high-tech exports almost doubled, rising from 18 percent in 1990 to 35 percent in 2000 (figure 3.2).

Figure 3.2 High-tech exports as percent of manufactured exports in the Republic of Korea, 1998–2000

High-tech exports as percent of manufactured exports
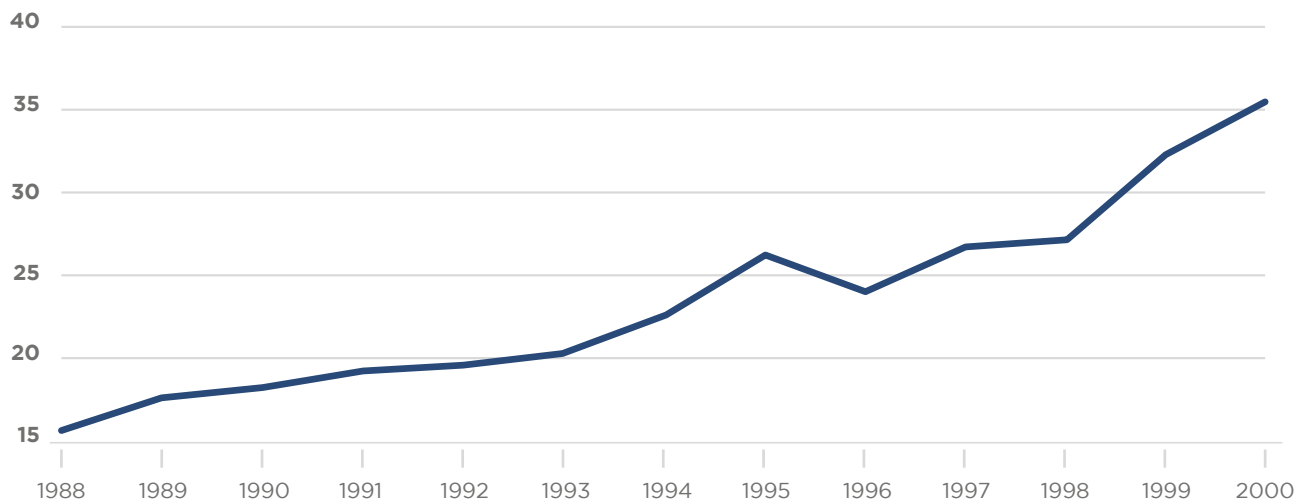
Source: World DataBank.

To continue the expansion of high-tech exports and establish itself as a strong IT economy in the 21st century, the government designed and implemented a master plan for ICT education, which it updated every four to five years. The nationwide ICT master plans sought to (a) establish an ecosystem that is conducive to equipping students with global competitiveness and (b) find solutions to education problems (KERIS 2009).

The national vision set as part of the First Master Plan of ICT Education (MP1), created in 1996, was "to establish an open education society, a lifelong learning society, and an updated education and welfare society based on ICT, where anyone can access education with no limitation on time and space" (MOE 1998, p. 9). Specific objectives that support this vision included the following (MOE 1998, pp. 10–11):

1. To achieve open education and a lifelong learning education society where anyone, with no limitation on time or space, can access information through state-of-the-art technology.

2. To offer quality education, led by a quality teacher in a quality school, to all students regardless of their location, socioeconomic background, or disability status.

3. To become globally known for strong ICT education in the 21st century.

4. To shift the education paradigm to align with the information society: a shift from provider-focused to consumer-focused education, a shift to education free from space and time, a shift from knowledge consumption to knowledge creation and distribution, a shift from one-size-fits-all to individualized education, a shift from the role of teachers as instructors to facilitators, etc.

5. To design an educational administrative system that is simple and efficient.

This vision and these objectives imply that the government approached ICT education as a vehicle or a necessary tool to transition into the information society. Objective 4 urges the education system to discard obsolete practices and seek alternatives that align with the information society. The term informatization of education, which is used in Korea to indicate ICT education, reflects this interpretation; it refers to comprehensive education reform and a paradigm shift. The Ministry of Education (1998, p. 9) defined the informatization of education as

> the restructuring of an education system, which includes the diversification and improvement of educational contents, methodology, and modes of education, through integrating technology into education. It also promotes changes in mindset and attitudes to better adapt to an information society and achieve education that is flexible, productive, and efficient.

Another key dimension that underlies the vision and objectives of MP1 is the equity approach to ICT education. Access to information, technology, and quality education does not discriminate based on socioeconomic background, or disability status. The concept of open education and lifelong learning allows people to enjoy learning without any time and space constraints (Objectives 1 and 2).

Tackling the digital divide by supporting access to technology runs through the master plans (table 3.1). According to OECD data, Korea spent 7.6 percent of its GDP on education in 2012. This level of spending is on par with spending in Denmark (7.9 percent) and Finland (6.5 percent). But more than a third of these expenses were by households (2.8 percent), a much larger share than in Denmark (0.4 percent) or Finland (0.1 percent). In addition, spending varies widely across income groups, creating unequal opportunities for students.[13] In response, the government introduced and integrated technology into education as a potential equalizer intended to level the playing field for students from various socioeconomic backgrounds.

Table 3.1 Main themes of ICT master plans in the Republic of Korea, 2001–18

Master Plan	Main themes
MP2 (2001–05)	**1.** Create a cyberspace where anyone, at any time, can learn. **2.** Nurture creative manpower. **3.** Equip people with digital literacy and *tackle the digital divide by providing support to marginalized populations.* **4.** Increase the efficiency of the project by establishing relevant laws and policies and offering a transparent online education administrative system.
MP3 (2006–10)	**1.** Strengthen the learning capacity of Koreans through e-learning programs. **2.** Create a ubiquitous learning environment. **3.** Collaborate with developing countries on ICT education projects. **4.** *Tackle the digital divide by continuing to provide digital support to marginalized population*, and establish a system for cyber security.
MP4 (2010–14)	**1.** Depart from hardware-oriented ICT education, and reinforce software to enhance global competitiveness. **2.** Strengthen human capital and achieve strong IT economy by supporting the collaboration across experts from education and science through communication and interdisciplinary approach. **3.** Introduce concept of research + education ecosystem by establishing evidence-based education system.
MP5 (2014–18)	**1.** Offer creative education in preparation for the future. **2.** Support customized learning to inspire dreams and talents. **3.** *Provide equal opportunities* for education through coexistence and cooperation.

Source: KERIS 2002, 2006, 2012, 2014.
Note: Vision statements that addresses equity are in italics.

13• In 2010, the differences between the lowest and highest income groups were vast. Monthly household spending on learning English ranged from $15 to $150, and participation rates ranged from 20 percent to 70 percent (Kim 2012).

Establishment of the Korea Education and Research Information Service (KERIS)

To realize its vision for ICT education, the Ministry of Education considered two options for education reform: creating a bureau within the ministry or establishing an external agency to oversee the rollout of new technologies within the education system (Kwon and Jang 2017). It chose the second approach, creating the Korea Education and Research Information Service (KERIS) in January 1999. This option made sense given the nature of the task—orchestrating a paradigm shift in learning—which required continuous influx of external expertise over time (Kwon and Jang 2017). KERIS is funded and supervised by the Ministry of Education but remains largely autonomous in its day-to-day functions. It serves the dual roles of helping the Ministry of Education design ICT education plans and implementing the plans under the supervision of the ministry.

Master Plans for ICT Education

Every four to five years, KERIS designs and executes a master plan. To date it has completed five master plans (table 3.2). The plans have evolved from "building infrastructure and creating digital content for ICT education to supporting innovating teaching and learning processes to realize more individualized learning" (Kwon and Jang 2017, p. 39).[14]

Table 3.2 Features of master plans for ICT education in Korea, 1996–2018

Master Plan	Main Goal	Features
MP1 (1996–2000)	Build ICT infrastructure	• Each teacher received personal computer • One or two computer labs were installed in each school • KERIS was established
MP2 (2001–05)	Reinforce use of ICT	• The Cyber Home Learning System and the National Education Information System (NEIS) were launched
MP3 (2006–10)	Improve quality of ICT education	• The Revised National Curriculum was implemented • The digital textbook was developed
MP4 (2010–14)	Provide SMART (Self-directed, Motivated, Adaptive, Resourceful, and Technology) education	• An adaptative learning system was introduced to strengthen students' 21st century skills
MP5 (2014–18)	Promote student-centered learning	• Coding education became central to ICT education

14• The evolution of the master plans is also reflected in the leadership appointments to KERIS, which has had seven presidents. The first four had computer science backgrounds, the next two had management backgrounds, and the current president has a background in education. Appointing an ICT expert as a president in the earlier years was critical to navigating the ecology of ICT. Appointing an educator as president helped spearhead the shift in focus toward individualized learning (Kwon and Jang 2017).

First Master Plan (MP1): 1996–2000

MP1, rolled out in 1996, focused on establishing ICT infrastructure in schools. Computer labs were installed in all schools,[15] more than 10,000 schools were connected to the Internet, and every teacher at every level of education was given a personal computer to improve their teaching using ICT (MOE 1998; Plomp et al. 2009; Hwang, Yang, and Kim 2010). To support educational research and teaching in the classroom, the online education platform EDUNET was developed, and educational software and database were uploaded and distributed.

Teacher training under MP1 dealt largely with familiarizing teachers with the change in educational environment that the introduction of ICT created and supporting them in the use of technology and software for teaching and performing administrative tasks (MOE 1998). The goal was to offer basic ICT training to all teachers by 2000, training a quarter of teachers each year.

After the training, teachers were certified and incentivized to hold computer-related licenses by considering them in promotions (MOE 1998). The Ministry of Education developed the ICT Skill Standard for Teacher (ISST) to evaluate teachers based on "information gathering, information analysis and processing, information transfer and exchange, and information ethics and security" (Hwang, Yang, and Kim 2010, p. 76) to encourage their use of technology in teaching and ensure that it is applied at a high level.[16] In 1999, the Ministry of Education created KERIS as the lead agency on the design and implementation of ICT education policies in Korea.

15• In schools with more than 36 classrooms, two computer labs were set up per school. In smaller schools, on lab per school was created.
16• The ICT Skill Standard for Students (ISSS) was finalized under MP2. It had the same categories as ISST, but they were specified across five stages of grades (1–2, 3–4, 5–6, 7–9, and 10) (KERIS 2002).

Second Master Plan (MP2): 2001–05

The rapid distribution of computers at all levels of education continued in MP2. By the end of MP1, the number of students per computer was 15; by the end of MP2, this number had fallen to 7 (figure 3.3). MP1 sought to create the physical environment necessary for ICT education; the focus during MP2 was shifted to establishing a virtual environment—a cyberspace where students and teachers can freely interact and use resources (see table 3.1 for the vision of MP2).

Figure 3.3 Number of students per computer in primary schools in the Republic of Korea, 1991–2009

Number of students per computer
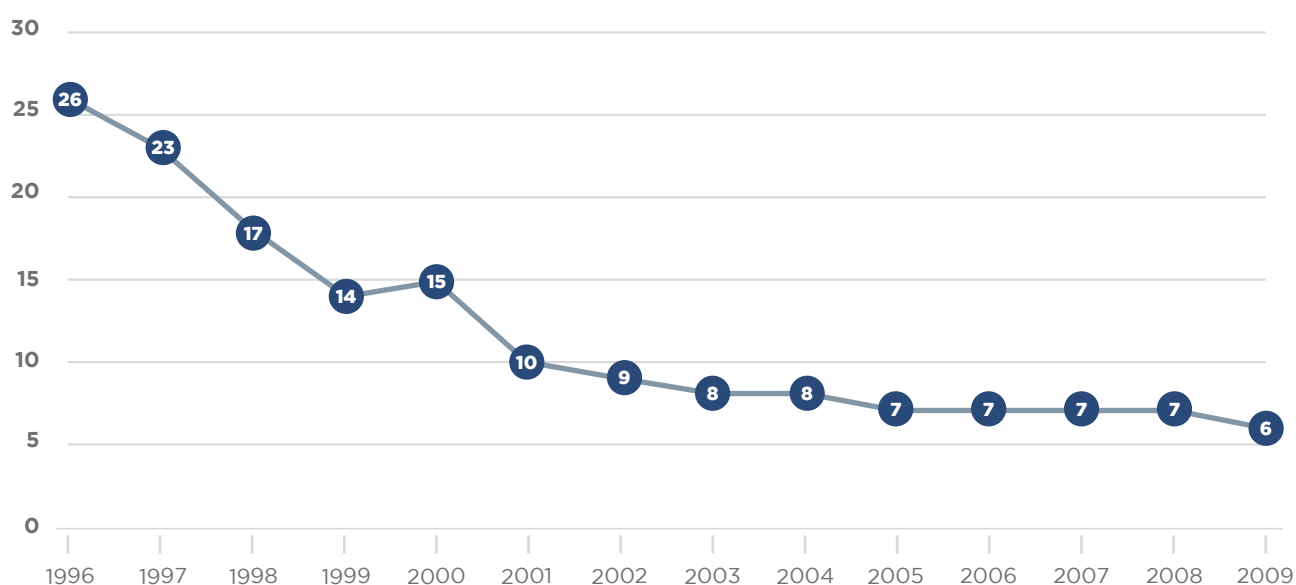
Source: KERIS 2009.

EDUNET, which provides lesson plans, teaching materials, and online courses, flourished, with 5 million registered users (teachers, students, parents). In addition, Cyber Home Learning System (CHLS) was launched, which provides individual online learning materials and tutorial support. Both EDUNET and CHLS help bridge the educational divide in private tutoring (part of the vision outlined in table 3.1), a problem in Korea (Hwang, Yang, and Kim 2010).

The focus for teachers in MP1 was to "learn about" ICT. Under MP2 it shifted to integrating and utilizing ICT (KERIS 2002). To promote teacher's participation and professional development, the Ministry of Education funded projects led by teacher interest groups to train fellow teachers and develop effective teaching materials. In 2003, the National Education Information System (NEIS) was developed to facilitate the electronic management of education-related administrative tasks (Hwang, Yang, and Kim 2010). It is maintained by KERIS.

Third Master Plan (MP3): 2006–10

Computer education was first provided in Korea's public education system in 1974, for high school students. By 1987, all students at all levels of education received such education. In 1997, fifth and sixth graders took two hours of computer class a week, and seventh and eighth graders took four hours a week. It was not until 2007 that the national curriculum took a leap, shifting its focus from "learning about computers" to "learning with/through ICT" (table 3.3).

Table 3.3 Changes in national curriculum on informatics in the Republic of Korea

Item	Seventh National Curriculum (1997–2006)		2007 Revised National Curriculum	
Name of subject	**Computers**		**Informatics**	
Content	1	Human and Computer	1	Composition and Operation of ICT
	2	The Basics of Computer	2	Communication and Management of Information
	3	Word Processor	3	Method and Process of Problem Solving
	4	PC and Internet	4	ICT and Information Society
	5	Multimedia		

Source: KERIS 2012.

Under MP3, all realms of education approached ICT as a tool to navigate the information society. As computers became more available, quality measures were added to ICT education. For example, capacity building of teachers was offered offline and online, and teachers were awarded for innovative practices, which later were distributed as best practices (KERIS 2006).

An interactive digital textbook was developed and tested; it later replaced physical books and lay the groundwork for SMART (Self-directed, Motivated, Adaptive, Resourceful, and Technology) Education under MP4. The digital textbook included workbooks, glossaries, and audio-visuals to support learning. It also allowed learning to be customized based on learner characteristics and the level of knowledge (Hwang, Yang, and Kim 2010).

Fourth Master Plan (MP4): 2010–14

The main project orchestrated under MP4 was SMART education, which KERIS defined as an adaptive learning system intended to strengthen the 21st century skills of students by innovating the entire education system, from the education environment, content, and methodology to assessment. The execution strategy for SMART education was defined in 2011. In 2013, third, fourth, fifth, and seventh grade social studies and science were selected as pilot subjects.

In addition to the digital textbooks, SMART education included five key areas:

- Development and application of digital textbook

- Capacity building of teachers on SMART education

- Free learning contents

- Promotion of online courses and assessment

- Development of cloud computing education service.

With regard to teacher training, 1,500 master teachers were selected and trained to develop skills for SMART education and to promote it by training fellow teachers, monitoring their practices, and providing feedback to relevant policies (KERIS 2012). In addition, upon the request of headteachers, master teachers visited schools to provide customized teacher training and offer school counseling based on the characteristics of each school environment. Another project that guided MP4 was securing free learning content developed from schools and public institutions and granting the public open access to it.

MP4 emphasize assessment, providing evidence-based learning and customized learning solutions. Cloud computing was a new concept introduced as part of SMART education. It offers a platform where teachers and students can freely access, share, and collaborate on available resources.

Fifth Master Plan (MP5): 2014–18

MP5 continued to promote customized and student-centered learning. It emphasized the use of ICT in vocational education and lifelong learning as a way to stay up to date with the rapidly changing needs of the labor market (KERIS 2015). The most significant changes that occurred under MP5 were the elevation of informatics to a compulsory subject and the introduction of coding as part of the curriculum. At the primary level (fifth and sixth grades), coding education was provided under the subject of home economics; since 2018, students have received a minimum of 17 hours of coding classes a year. In middle school, coding education was offered under informatics; students take at least 34 hours of classes a year.

As coding education became central to ICT education, the curriculum within informatics was overhauled. Under the 2007 Revised National Curriculum, the focus was on understanding the principles of ICT and using technology to communicate, solve problems, and actively engage in the information society. The emphasis in the 2015 Revised National Curriculum is on using data, programming as a method for problem solving, and understanding the mechanism of a computer. [17]

To support implementation of coding education, by 2018, 30 percent of primary school teachers had been trained in the subject and one teacher from each school was assigned as a teacher in charge of coding education. At the secondary level, more teachers were hired to teach informatics, and teachers with computer and informatics licenses were given additional training on coding education. Computer labs were updated, wireless networks were expanded, and in some schools, coding robots were provided to accommodate the new learning content (KERIS 2017b).

[17] • See https://itkyohak.blog.me/221099710362.

Lessons Learned from Implementing ICT Education in Korea

The Sixth Master Plan of ICT Education and its vision, "Cultivating a People-Centered, Future-intelligent Education Environment" (KERIS 2019), will set the foundation and guide the implementation of ICT education in Korea in the five years beginning in 2019. It has been almost 25 years since Korea drafted MP1 and proactively introduced and integrated technology into education. Table 3.4 summaries Korea's experience over this period.

Table 3.4 Main features of 25 years of experience with ICT education in the Republic of Korea

Feature	Approach
Vision for ICT education	• Equipped students with global competitiveness and explored solutions to address education problems in society. • Used ICT to tackle digital divide and other equity issues (such as disparity in educational opportunities based on socioeconomic status, urban/rural division, and disability status).
Implementation strategy	• Designed and implemented master plans for ICT education every four to five years, to assess and revisit achievements, stay up to date with technological advancements and pedagogical methods, and incorporate and update plan accordingly. • Created phases to implementing ICT education. Once a basic infrastructure is established, allocated resources to improving quality, through curriculum development, teaching materials, and teacher training, before shifting the focus to using technology for customized, evidence-based learning.
Infrastructure	• Defined the distribution strategy. To rapidly introduce technology into the classroom, the government first distributed computers to teachers (one teacher per computer) and established one or two computer labs per school (based on the number of classes). • Updated infrastructure along with the curriculum. The updating of the curriculum in the 2010s to offer individualized learning called for a new strategy for infrastructure. One device per student, Bring Your Own Device (BYOD),[a] and coding robots were introduced as part of software education.
Curriculum	• Shifted curricular focus from learning about computers (computer education) to learning with computers (informatics) to learning to program a computer (coding/software education). • Introduced informatics curriculum as elective, then extended hours before making it compulsory (in 2015).
Teacher training	• Diversified channels for teacher training to include offline and online, and made training more accessible. • Promoted integration of technology into classrooms by incentivizing teachers to hold computer licenses, investing in teachers' interest groups on ICT education, and sharing best practices across the country.

Note: a. Bring Your Own Device (BYOD) in education refers to permitting students to bring personal devices (laptops, smartphones, etc.) to school and use them to access information and services to support learning.

Addressing Challenges and Moving Forward

At the end of the 20th century, Korea crafted a clear national vision on ICT education; designed, updated, and implemented master plans for ICT education every four to five years; strategically shifted the focus from infrastructure and digital content to individual learning, as plans evolved and became more mature; and meticulously designed and implemented its plans through an external public institution (KERIS), under the supervision of Ministry of Education. These achievements are impressive.

Challenges remain, however. Korean students perform well on international assessments of computer-based reading and math skills, for example, but poorly on qualitative measures, such as interest in, familiarity with, and use of ICT to solve problems. Korea ranked in the top three on both computer-based reading and math skills on the 2012 PISA. On the 2015 PISA ICT Familiarity Survey, however, it ranked 30th out of 31 countries on attitude toward ICT, use of computers for learning, access and frequency of use of ICT in and out of school, school ICT infrastructure, and other measures (KERIS 2017a).

Will Korea generate positive results in other areas that are critical in the 21st century, such as creativity, collaboration, and problem-solving skills? The dismal results of the PISA ICT Familiarity Survey suggest that challenges remain.

Schools have not yet "owned" the shift toward education with technology. For example, the concept of digital textbooks emerged in MP3, was piloted in schools as part of SMART education under MP4, and was widely promoted under MP5. At the beginning of MP6, however, digital books had still not been fully accepted by the school community or fully incorporated into elementary schools.

Infrastructure provided 20 years ago has become obsolete and cannot support the new module of individual learning. And even with the update of the curriculum, the assessment method remains largely unchanged, thereby perpetuating the practices of rote memorization by students. Introduction of coding education in the curriculum has led to mushrooming of coding classes in the private sector, which burdens households and widens the learning gap between students from different backgrounds.

Korea needs to confront and address the elephant in the room: gaining consensus from the school community that technology is necessary for future learning. It needs to explore how to make technology effective for learning and offer effective learning for everyone.

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Chapter 4

Alessia Zucchetti, Cristóbal Cobo, and Mariana Montaldo

Integrating Information and Communications Techology into Education:
Uruguay

Alessia Zucchetti, Cristóbal Cobo, and Mariana Montaldo

Uruguay's economy and society have undergone significant changes over the past three decades. Since 2013, the country has been a high-income country, comparable to Western economies in terms of political, social, and economic stability.

Uruguay engaged in sustained political and institutional efforts to reduce inequalities, deploying social policies to reduce extreme poverty (World Bank 2017). As a result, it now has one of the highest rates of access to services and opportunities in Latin America, and it ranks very high in human development, with a value of 0.804 in 2017 (UNDP 2018).

Information and communication technologies (ICT) permeate every aspect of society. Access to digital technologies, along with the skills to effectively use them, will therefore continue to be essential for consolidating democracy and economic prosperity (Internet Society 2017).

In Uruguay, transformation toward a technology-driven society relied on various initiatives. One was the creation of the first nationwide program for digital inclusion in the world. Plan Ceibal (Proyecto Conectividad Educativa de Informática Básica para el Aprendizaje en Línea), adopted in 2007, was one of the first policies to spur social, technological, and economic development. It promotes social equity and access to digital technologies in the public education system, gradually integrating ICT into teaching and learning practices.

Providing access to digital technologies required bridging the digital divide. Uruguay did so by creating infrastructure, promoting access to devices and connectivity, and providing a suite of tools for enhancing education through ICT. Plan Ceibal has been a fundamental pillar of Uruguay's interinstitutional efforts to encourage the transition toward a knowledge-based society. The latest efforts required the adoption of a comprehensive conception of development in which the digital and social transition are closely related to education policymaking.

Uruguay worked across various transversal areas:

- It has been actively engaged in international and regional ICT initiatives, such as the World Summit on the Information Society (WSIS).

- It played an active role in the processes leading to the creation of the regional digital agendas (eLAC).[18] It has participated in diverse collaborative and multistakeholder initiatives, such as consecutive editions of the global Internet Governance Forum (IGF),[19] the organization of the national IGFs,[20] and the working group Digital 9. [21]

- beginning in the 2000s, It established interinstitutional structures and policy instruments such as the Digital Agenda for Uruguay (2007–08, 2008–10, 2011–15, 2018, 2020) and the 2010 National Strategic Plan for Science, Technology, and Innovation (PENCTI), among others.

- Recently, other interinstitutional initiatives have been emerging in novel areas, such as the Committee of Ethics for the use of Data in Education, led by the Ceibal Foundation, with the support of Plan Ceibal.

Plan Ceibal oversaw the delivery of more than 1.5 million half devices (reaching universal access among students and teachers in all preschool, primary, and secondary schools) and the connection of all educational centers in Uruguay to the Internet. It developed a suite of applications for enhancing teaching and learning practices, providing education services as online teaching and learning platforms, digital educational resources, virtual classrooms, and management and monitoring tools. Plan Ceibal has reached more than 700,000 beneficiaries in a country of 3.4 million people (World Bank 2017).

The program's initial phase focused on reducing the digital divide and securing ICT access. The program then supported targeted educational initiatives that bridge the gaps between schooling, learning, and employability (World Bank 2018).

This case study on Uruguay sheds light on the potential of digital technologies, the impact of technology-driven transformations, and the transition toward a knowledge-based society. It also highlights the diverse and intertwined policy mechanisms and institutional architecture behind digital transition.[22]

This chapter examines the technological and digital transformation of education in Uruguay. The first section looks at the economic and technological transition, which began in the early 2000s. The second section describes the interinstitutional architecture created and the changes that have been made to it. The third section focuses on the connection between technology and education, which Uruguay achieved through Plan Ceibal. The last section draws conclusions and recommends best practices that can be useful for other countries.

18• eLAC refers to the Latin America and Caribbean plan of action for the information society. Since the first intergovernmental meeting, held in 2000, participating countries have agreed on eLAC 2007, eLAC 2010, eLAC 2015, eLAC 2018, and eLAC 2020. For more information, see the eLAC2020 website (https://www.cepal.org/es/proyectos/elac2020).
19• The Internet Governance Forum (IGF) is the global platform for multistakeholder policy dialogue related to Internet governance. Every year since its creation, in 2006, it has brought together diverse stakeholder groups to discuss Internet-related policies and issues and exchange and share best practices (United Nations n.d.). For more information see https://www.intgovforum.org/multilingual/content/about-igf-faqs.
20• National and regional initiatives are organized within the framework of the global IGF. They facilitate discussions of Internet governance in accordance with the principles of the global IGF with a national or regional focus (United Nations n.d.). For more information, see https://www.intgovforum.org/multilingual/content/igf-regional-and-national-initiatives. By 2018, three national IGFs had been held in Uruguay.
21• Digital 9 is a working group of leading countries in digital-related issues. Uruguay was the first Latin American country to join the group (Uruguay XXI 2018).
**22•** Uruguay's national initiatives for ICT integration are extremely comprehensive and cover several areas other than the ones presented in the current chapter.

The Economic and Technological Transition

During the late 1990s and early 2000s, the ICT sector started to be thought of as a path toward economic growth and social inclusion in Latin America (Hilbert, Bustos, and Ferraz 2005). Public- private partnerships led to important investments in wireless technologies, leading to rapid growth in ICT worldwide (World Bank 2014; WEF 2014). The need to tackle weaknesses in innovation systems; achieve sustained economic growth; and address structural socioeconomic issues, particularly social inequalities, influenced the adoption and uptake of national ICT policies in many Latin American countries (WEF 2014; OECD 2014).

Digital and technological uptake played a significant role in Uruguay's recent development. Uruguay's economy began to improve only after the financial crisis of 2002 (Hausmann, Rodríguez-Clare, and Rodrik, 2005). In 2002, per capita GDP in Uruguay was less than $10,000 a year, and only 3 percent of manufactured exports were categorized as high technology. By 2015, GDP per capita had more than doubled and the share of high-tech exports had risen to 14 percent of manufactured exports (figure 4.1).

Figure 4.1 GDP per capita and high-tech exports in Uruguay, 1995–2015
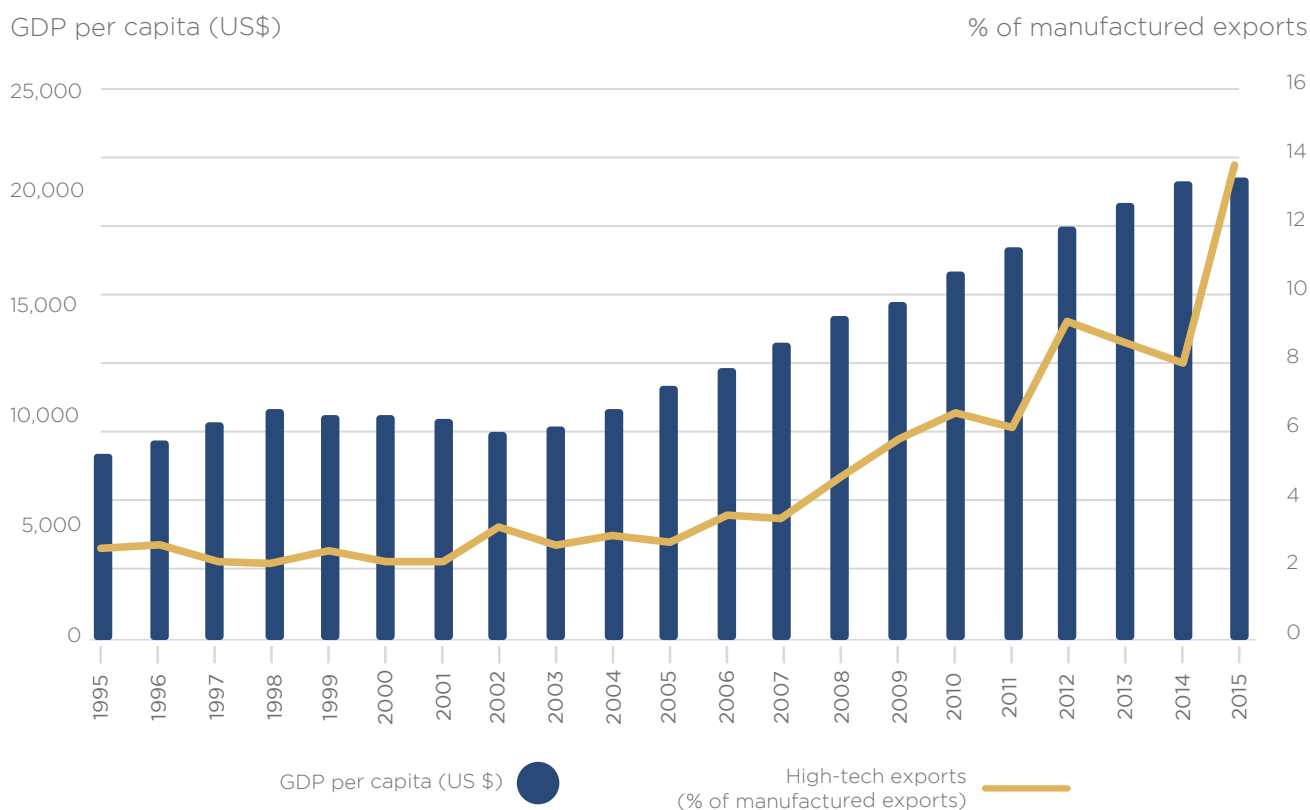

Source: World DataBank 2019.

The economic improvement of the early 2000s created enabling conditions for introducing various measures beginning in 2005. They included actions to promote the deployment of infrastructure and connectivity, provide access to ICT, bridge the digital divide, guarantee social inclusion through the integration of ICT in education, and spur the deployment of e-government services. Digital and technological strategies were part of a broad development conception in which research, innovation, and ICT were pillars for improving socioeconomic conditions and well-being (Gabinete Ministerial de Innovación 2010).

The transition is reflected in Uruguay's ranking on the World Economic Forum's Networked Readiness Index (NRI).[23] In 2006, Uruguay ranked 65th out of 115 countries (UNCTAD 2006). By 2016, it had risen to 43rd place (WEF 2016).

Toward the Digital Transition:
Uruguay's Participation in International, Regional, and National Initiatives

Regional efforts for promoting ICT integration in the economy and society started in the early 2000s. They gradually led to the adaptation of those instruments to the national context.

Discussions about the role of research, innovation, and ICT for economic development acquired substantial relevance in academic and political circles in Latin America during the early 1990s. Before then, development studies put a strong emphasis on investments in research and development as a means of addressing structural bottlenecks in developing countries (Sunkel and Paz 1970).
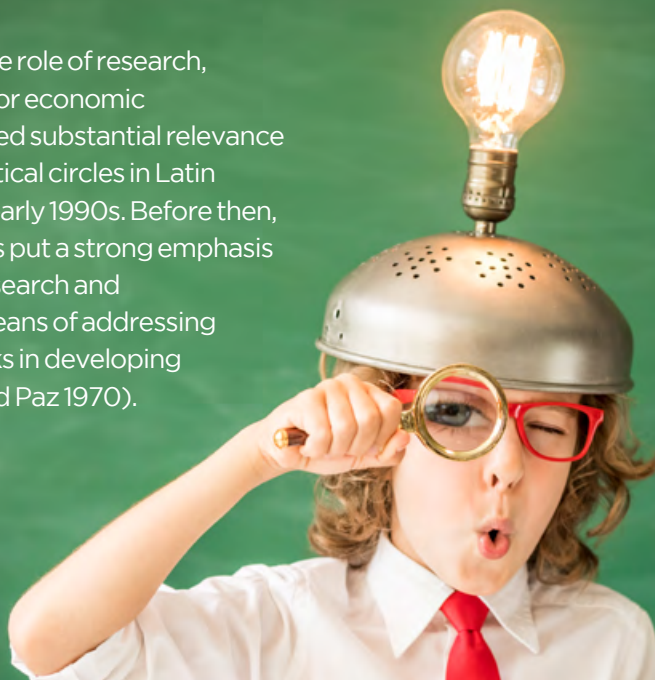
23• The NRI is an international framework for measuring the capacity of countries to leverage ICT opportunities. It includes three subindexes, on (a) the environment (individual, political/regulatory, and infrastructure); (b) readiness (individual, government, and business); and (c) usage (individual, government, and business) (WEF 2016).

Policy development concerning the ICT sector was initially driven by the work of the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), as well as intergovernmental initiatives that allowed countries in the region to start working on common frameworks. One of the first examples was the intergovernmental summit on the information society of the 2000s and the adoption of the Declaration of Florianópolis, the first regional declaration on the ICT sector (Hilbert, Bustos, and Ferraz 2005). Several governments in the region, including Uruguay's, strengthened their commitment to create public programs for promoting universal access to ICT, deploying adequate digital infrastructure and supporting research and innovation (Peres and Hilbert 2009).

Uruguay was actively involved in international and regional discussions about the development of the information society. It participated in the first two World Summits on the Information Society (WSIS), held in Geneva in 2003 and Tunis in 2005.[24] Both are milestones in the recent history of the Internet and ICT-related policies. The meetings led to the Geneva Declaration of Principles, the Geneva Plan of Action, the Tunis Commitment, and the Tunis Agenda for the Information Society (ITU 2005). These documents reflected strong commitments from all stakeholder groups to bridge the global digital divide; promote infrastructure deployment; and integrate ICT across several areas, including education, health, and the environment. The IGF and the multistakeholder approach to Internet-related issues are also a result of this process.

Uruguay participated in all WSIS meetings since 2003, including the WSIS+10 process (World Bank 2014).[25]

Uruguay also engaged in regional forums and discussions that led to various versions of the eLAC regional digital agendas, starting with the adoption of the first action plan for the information society, eLAC 2007) (CEPAL 2008). The country played an active role in regional and international discussions leading to eLAC 2015 and eLAC 2018, which focus on monitoring the integration of ICT across transversal areas such as access, government, education, the environment, social security, and economic development (CEPAL, 2010; 2015). In 2018, the Sixth Ministerial Conference on the Information Society in Latin America and the Caribbean concluded with the adoption of eLAC 2020. The latest reflects the new challenges emerging in the digital ecosystem, in particular regarding the massive collection and processing of data and advances in artificial intelligence, the Internet of things, and blockchain.

24• See https://www.itu.int/net/wsis/.
25• The WSIS+10 process reviewed the progress made since implementation of the WSIS Plan of Action adopted in Geneva in 2003 (ITU 2014).

Uruguay has implemented other actions at the national level. In 2005, it created the Agency for the Electronic Government and the Information Society (AGESIC), one of the first actions for promoting the digital and technological transition. The focus on ICT integration and technological uptake across the economy and society also responded to the need to boost scientific capacity-building and innovation (Gabinete Ministerial de Innovación, 2010).

Uruguay also created the National Agency of Innovation within the scope of the Ministry of Education and Culture; the Ministry of Economy and Finances; the Ministry of Livestock, Agriculture, and Fisheries; and the Direction for Planning and Budget. At the end of 2006, it became the National Agency for Research and Innovation (ANII), a nongovernmental public institution. In 2007, the nationwide digital education program, Plan Ceibal (Conectividad Educativa de Informática Básica para el Aprendizaje en Línea) started its activities. By the second half of 2008, Uruguay had its first digital agenda, ADU (Agenda Digital de Uruguay) 2007–08. It acknowledged Uruguay's international and regional positions regarding the information society and articulated various initiatives and projects for integrating ICT (AGESIC, 2008).

The first area of action on the agenda was the promotion of access, equity, and inclusion through education, through Plan Ceibal. The main objective was to provide all teachers and students with devices that could improve their education. The goal was to deliver 100,000 devices by 2008 (AGESIC, 2008). The commission in charge of the project was formed by representatives of the Ministry of Education and Culture, the National Administration for Public Education (ANEP), the Technological Laboratory of Uruguay (LATU), the National Telecommunications Administration (ANTEL), AGESIC, and ANII (AGESIC, 2008).

The Role of Technology in the Transformation of the Education System

Inception, Institutional Design, and History of Plan Ceibal

Since its creation, in 2007, Plan Ceibal has been an essential part of Uruguay's development strategy. It was created to bridge the digital divide in Uruguay. The program was inspired by the 1:1 (one laptop per child) model developed by Nicholas Negroponte at the Massachusetts Institute of Technology (MIT) (Rivoir and Lamschtein 2012). Uruguay was the first country to adapt and implement the program at a national scale.

Ceibal was established in 2007 by an executive decree. Its creation responded to the need to advance toward an information and knowledge society, addressing the digital divide. The decree acknowledged the role of the school as a privileged environment for social integration, the country's technological and human capabilities for providing connectivity to the public education system. During the initial phase, an interinstitutional commission was in charge of the actions needed to reach Plan Ceibal goals. Technical and operational implementation was entrusted to the Technological Laboratory of Uruguay (LATU). [26]

26• The Technological Laboratory of Uruguay (LATU) is a nongovernmental public institution created by law in 1965, with the objective of promoting the country's sustainable development through innovation, technology transfer, and services with added-value (LATU 2019).

In 2010, the Ceibal Center was established, as a nonstate/nongovernmental public institution, to oversee Plan Ceibal activities. A multistakeholder, interinstitutional council, consisting of representatives of the Ministry of Education and Culture, the Ministry of Economy and Finance, and ANEP, oversees its activities. All of the initiatives supported by Plan Ceibal were implemented in close coordination with relevant institutions and stakeholders, especially ANEP, the Ministry of Education and Culture, the Council for Teacher Training, the Presidency of the Republic, and various agencies. This institutional structure favors the coordination of the initiatives adopted.

Plan Ceibal went through three phases. The first phase sought to secure access to connectivity and devices for all children and teachers in the public educational system, first in primary school and then in middle school. These objectives were also part of other interinstitutional policy frameworks, such as the Digital Agenda for the Information Society (2007–08) and subsequent versions (AGESIC 2008). The second phase, which began in 2010, promoted teachers' professional development, by providing training and capacity building. The third (current) phase is characterized by the development of new programs and initiatives in a variety of areas, such as 21st century skills, deep learning, robotics, coding, research in education and ICT, and digital inclusion for older adults, among others.

Moving beyond Technology

After three years of implementation, the conditions for moving beyond technology had been created. In 2006, before the creation of Plan Ceibal, the share of the population with an ICT device at home was less than 6 percent in the lowest income quintile and almost 49 percent in the highest income. By 2010, those percentages had increased to 60 percent and 65 percent, respectively. Between 2007 and 2017, the digital divide narrowed significantly (figure 4.2).

Figure 4.2 Access to a computer in Uruguay, by age and income quintile, 2007 and 2017
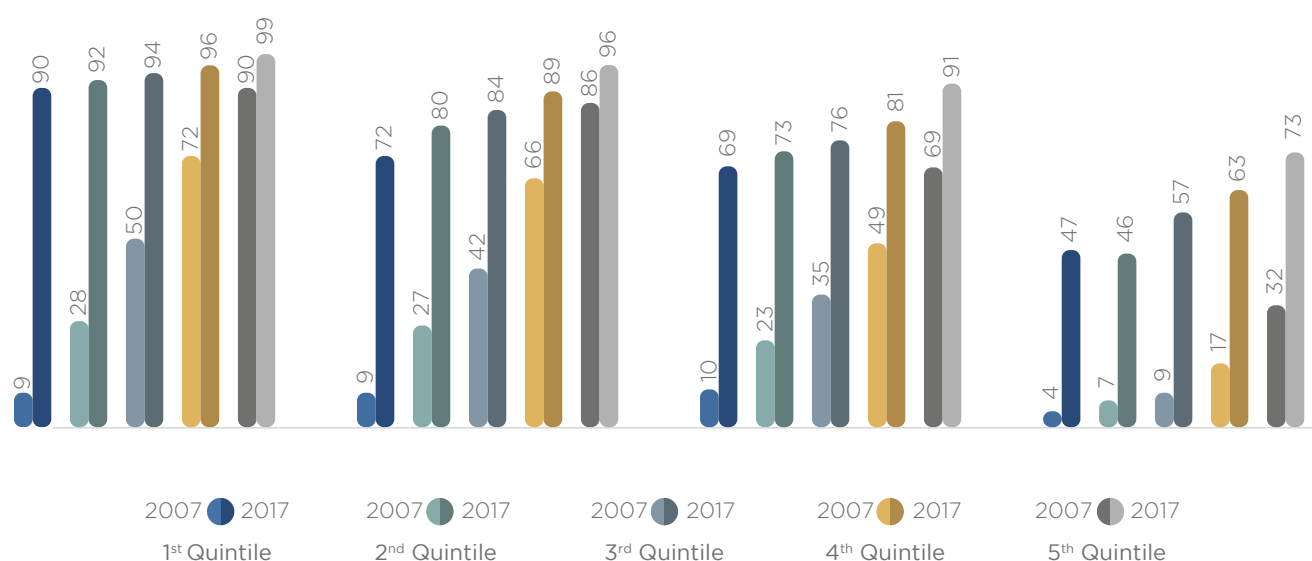
Source: Plan Ceibal.

More than 1.5 million half devices have been delivered, reaching universal access among students and teachers at the preschool, primary, and secondary levels. Every educational center in the country is now connected to the Internet; 2,500 centers have WiFi connectivity and 1,500 are equipped with videoconferencing equipment.

With the expansion of technology in schools, it was possible to focus on other social challenges, such as creating innovative educational programs, developing digital skills among educators, and improving and fostering new pedagogical approaches. Under Ceibal, technology is not the center of the learning experience but an enabler that allows projects to unfold and succeed. The plan established several long-term projects focused on training teachers; promoting the introduction of innovative forms of learning, teaching, and evaluating; and improving students' competencies and abilities across a wide diversity of areas, including the following:

- New pedagogies for deep learning

- Innovative training for problem solving

- Videoconferencing for teaching English as a second language

- Robotics and computational thinking

- Reacher development and training

- Online educational content

- Online platforms for learning and evaluation

- Learning management systems, such as-CREA and CREA2 (virtual learning environments)

- Educational videogames and apps

- Research in education and technology

- Social and digital inclusion

- Digital inclusion of older adults

- Instruction in learning to code for people 17–26

- Learning assessment and management tools for the education system.

Examples include the following:

• Teaching of English: The Ceibal in English program combines online and classroom learning. As part of an agreement with the British Council, students in the fourth, fifth, and sixth grades of primary school attend English classes taught online by a native English speaker via videoconference. A local teacher acts as a facilitator for the online classes. This teacher implements the guidelines and programs prepared for these courses. Teachers participating in this program receive training to help them implement it. The program serves 70 percent of the education system (the other 30 percent is covered by ANEP's Second Language Teaching Program). The English Adaptive Assessment (Evaluación Adaptativa de Inglés) shows that online learning is as strong as in-classroom learning and that students at all socioeconomic levels benefit from it. The share of sixth grader students performing at proficiency level A2 (advanced beginner, according to the Common European Framework of Reference for Languages Learning, Teaching, and Assessment) was 66 percent in 2016 and 79 percent in 2017 (Plan Ceibal 2017, 2018).
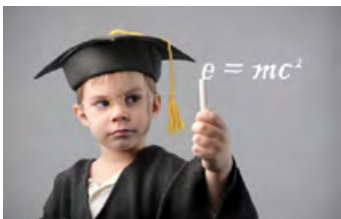
• Math Skills Performance: Integration of the Adaptive Mathematics Platform (Plataforma Adaptativa de Matemática [PAM]) into the education system supports classroom work. A panel study that examined a group 2,143 students from 237 public and private schools in 2013, when they were in third grade, and 2016, when they were in sixth grade, finds that PAM had a positive effect on learning (Perera and Aboal 2017).

• Biblioteca País. In 2011, Ceibal created a small digital library to address the limited access to textbooks in Uruguay. It provides access to all textbooks recommended by the education system through ninth grade at no cost. Since December 2018, the digital library, which has more than 4,500 resources, has been available to all Uruguayans.

• Ceilab. Ceilab seeks to create spaces in schools where students can think, design, prototype, and develop their ideas with the active use of technology. Schools are required to customize a particular set of innovative technologies (drones, 3D printers, sensors, Lego kits) as part of a catalogue. The Ceilab team works with teachers and students in designing spaces, selecting what needs to be developed for each project.

• Coding and robotics: Using coding software such as App Inventor and Scratch, students, in collaboration with teachers, are encouraged to create their own applications and games in response to challenges and topics designated by Ceibal and ANEP. In 2018, for example, the challenge was to obtain and preserve clean water. In 2017 students developed ideas for sustainable cities (Álvarez 2017).

Conclusion, Policy Implications, and Lessons Learned

During its nearly 12 years of existence, Plan Ceibal has delivered ICT devices and Internet connectivity and used ICT as a pillar for introducing a suite of tools and resources for enhancing the learning and teaching experience. Plan Ceibal has promoted new pedagogic models and trained teachers in their use, introducing new forms of learning with or without technology that aim to prepare students for a digital society.

Introduction of the program created an ecosystem of innovative transformations. Students and teachers are encouraged to use technology in innovative ways that are relevant for each context and to explore and experiment. Projects are gradually introducing a new way of thinking and constructing knowledge among teachers and students based on self-driven learning, collaboration, team-building activities, and problem-solving. Knowledge is built collectively through networks of schools, labs of robotics, communities of practices (mainly of teachers), and national innovation contests, among other projects.

Factors Contributing to the Success of Plan Ceibal

Three main factors contributed to the success of the program.

A focus on pedagogy, not only technology
Plan Ceibal's activities are inspired by the idea of learning as an active, contextualized process of constructing knowledge rather than simply valuing its acquisition from external sources. Technological tools can help enrich learning, but they need to be integrated with the idea of learning by doing.

Facilitation of community building, communities of practice, and networking Plan
Ceibal facilitates and promotes spaces in which to socialize and disseminate knowledge. It facilitates and promotes regular meetings and gatherings of all of the diverse institutions involved in its structure. It supports meetings of educators, at which they can facilitate and promote learning exchanges, share good practices, build trust, and consolidate the community of actors who support the adoption of technology in the learning environment. Teachers meet to take part in training and development events as well as to share their experiences. In virtual or face-to-face contexts, educators share their concerns or let others know what approaches have not worked as planned.

Learners also meet and connect with others, either face-to-face or online. This social experience is considered critical for promoting the sharing of good practices, project-based learning, and bottom-up innovations, among other issues.

An important part of the cultural transformation within the educational system is grounded in having different contexts and spaces (physical and virtual) for sharing and transferring good practices and positive experiences that can enrich the work of others. This vision has been nurtured by systematically holding annual gatherings (including a national contest on robotics, design meetings, and national teacher development events), where the most remarkable experiences are shared or communicated on a national scale.

Development of a culture of accountability

Plan Ceibal has been a pioneer in evaluating its performance. In 2008, when it started to expand to the inner provinces of the country, its monitoring and evaluation department carried out its first evaluation. Since then, Ceibal has continued to monitor and evaluate implementation of this public policy (by designing, executing, or participating in studies). The goal is to produce systematic and rigorous information on the processes, results, and impact of Plan Ceibal. This information is used as an input in decision making on both institutional strategy and operational management of technical teams. The creation of an independent research center (the Ceibal Foundation), in 2014, is another example of a step taken to create evidence that can support decision making and help understand the use and potential of digital technologies.

Plan Ceibal started participating in international studies in 2017. Two examples are Kids Online Uruguay and the International Computer and Information Literacy Study (ICILS). Uruguay participates in Kids Online through a coordinated effort between UNICEF, UNESCO, AGESIC, Ceibal, and the Catholic University of Uruguay. The ICILS the study is conducted by the International Association for Evaluation of the Educational Achievement (The Netherlands), with the support of Plan Ceibal and the Ceibal Foundation for Uruguay.

Summary

Deep transformations happen when actors transform their practices. The value of a digital educational policy lies not in the introduction of novel gadgets but in its capacity to offer new possibilities for different forms of learning.

Innovation is relevant only when it can be scaled up to the whole education system. For that reason, Ceibal has helped create an innovation ecosystem that brings equity and new opportunities to current and coming generations of learners and educators.

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Incorporating 21st Century Skills

Chapter 5

Joseph South, Brandon Olszewski, and Yolanda Ramos

Reforming Education in Response to the Skill Shifts in the Labor Market: United States

Joseph South, Brandon Olszewski, and Yolanda Ramos

Traditional mass education was developed during the Industrial Age, in large part to prepare a workforce for an industrial economy. That system relied on fixed amounts of seat time, mandated learning content, classroom activities managed by a central authority (the teacher), segmented curriculum subjects and academic tracks, and learning goals and content that were often far removed from the requirements of the jobs students needed after graduation (Chubb and Moe 1990).

This "factory model" of education may have been adequate for 20th century industrial economies, where a foundation of basic skills in literacy, numeracy, and other core subjects allowed students to enter the bottom rungs of the job market. But the rapid technological change of the late 20th and early 21st centuries engendered radical changes in the workforce—in the types of work done, in how people complete the work, and in the skills that businesses need to thrive.

This transition from an industrial economy to an information economy built on constant, ubiquitous digital connectivity and communication—sometimes referred to as the Fourth Industrial Revolution—demands a change in the education system. But for the most part, schools have not risen to the challenge, and the factory model of education continues as the dominant paradigm for schooling. This mismatch makes the model of mass education and the needs of advanced economies incompatible with each other. To once again become relevant, education needs to radically change.

Since 1979, the International Society for Technology in Education has worked to create and implement frameworks to rethink and innovate education that integrate digital technologies and guide the development of skills required by young people to effectively live, study and work in the Fourth Industrial Revolution.

This chapter focuses on some of the most powerful changes that can be made in today's education system to align what is done in school with the shifting skills required in modern democracies and labor markets. The first section explores the future of work and the types of skills workers need to have in order to be competitive in current and future labor markets, historically situating the promise of new forms of personalized learning. The second section discusses the foundation for digital-age learning, focusing on professional learning goals related to competencies that today's students must have in order to be successful in school and at work, defined as the International Society for Technology in Education (ISTE) Standards. Section three examines the logistics of implementing digital-age learning. It discusses applications of various educational technologies and provides recommendations for systemic change, such as building transformation plans on a framework (the ISTE Essential Conditions) that describe foundational elements of effective educational transformation. The last section examines the implications of computational thinking in an increasingly technological world.

The Promise of Personalized Learning

Today's world is more connected than ever before, largely thanks to the power of digital technologies. Many countries across the globe are experiencing parallel trends in commerce, the workforce, and education. These changes allow for powerful human networks to leverage complex data and computational networks to provide highly personalized experiences for each individual. Technology connects and customizes people's experiences—shopping, entertaining, exercising— to meet their needs, individual tastes and decision making. Technology also helps predict future needs.

Imagine if the educational system were designed with the same values and approach. Learning would be customized to the individual needs and interests of students, and what they needed to do next or whom they needed to interact with or learn from could be anticipated, allowing them to learn at the pace that is right for them, with the right support and mentoring to assist them at the best moments for learning. This is the promise of personalized, competency-based learning.

New Skills for a New Economy

Even if it were possible to make these changes (how to teach) in every school, schools would still need to update what to teach, to match the new skills and competencies that this new economy requires and prioritizes. Above and beyond basic skill deficits in literacy and numeracy, which affect as many as one in six adults (OECD 2013), technologically driven transformations are giving rise to new skills gaps. Bughin et al. (2018) identify the most important labor market skills as follows:

- Advanced technological skills, especially information technology (IT) and programming

- Advanced social and emotional skills

- Advanced cognitive skills, including creativity, critical thinking, and complex information processing.

Advanced Technological Skills

Whether people are prepared for it or not, much of the future economy will rely on increased automation and machine learning. A 2013 Oxford University study estimates that 47 percent of U.S. jobs could be replaced by robots and automated technology within the next two decades (Frey and Osborne 2013).[27] Advanced technological skills in the new workforce require a deep understanding of how machines use data and pattern recognition to improve the algorithms they use to solve problems.

The education system can address these new areas by teaching the building blocks of computational thinking, the fundamentals of artificial intelligence, and the discipline of computer science, including coding. It is not enough to understand what machines can do for humans or what jobs they may replace. Students need to understand how machines work and how to program them to solve the problems that matter. These new fundamental competencies can no longer be ignored or made available to only a privileged few.

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[27]• Substantial disagreement remains regarding the extent of job displacement from technology, including automation and artificial intelligence. A report by McKinsey (Bughin et al. 2018) suggests that by 2030, the time spent using advanced technological skills will increase by 50 percent for American workers, although such changes may not necessarily result in job loss (Kinder 2018). Some studies claim that the extent of job creation that will likely result from workforce changes will be minimal (Bakhshi et al. 2017). Others predict that some jobs will disappear but that others that do not yet exist will become common and that the workforce will need to align its skillset to keep pace (Gray 2016).

Advanced Social and Emotional Skills

As machines do more tasks at work—assembling appliances, writing legal contracts, calculating taxes—humans need to consider and capitalize on how their skills can best complement the automated help that machines provide, leveraging their labor to optimize the relationships that serve as a foundation for productive and trusted work-related transactions. Such attributes and skills are obviously useful in service-oriented industries. But what about highly technical industries? How relevant are they at a technological powerhouse like Google?

Google's Project Oxygen turned conventional wisdom on its head when researchers explored a mountain of human resources data on the characteristics of employees that most strongly predicted success. Of the eight most important qualities of Google's top employees, expertise in science and technology ranked last. The most important characteristics were coaching others; communication skills; understanding cultural differences and diverse points of view; empathy and support for colleagues; critical thinking and problem solving; and making connections across complex ideas (Strauss 2017). Such findings confirm that the skills at the core of today's economy have fundamentally shifted.

Advanced Cognitive Skills

While the top five skills in the Google study were all social and emotional in nature, the next ones were advanced cognitive skills—namely, being a good critical thinker, being a problem solver, and being able to make connections across complex ideas. Skills like these will become ever more important as economies shift from being dominated by employers that engage workers on a full-time basis over several years to more nimble employers that hire workers on an on-demand basis. In this new "gig economy," workers are employed project by project or assignment by assignment.

This kind of episodic employment is increasing rapidly. For some, it is no longer about making money on the side; episodic employment now represents their primary income stream. Gig economy employment increased by about 60 percent between 1997 and 2014, at a time when U.S. payroll employment rose by just 12 percent, according to the Brookings Institution (Hathaway and Muro 2016). These kinds of economic forces place a premium on remote workers who can add value as digital creators and problem solvers and on workers who can quickly understand what needs to be done and apply their skills creatively and collaboratively for the greatest impact in the least amount of time.

The Foundation for Digital-Age Learning

The ISTE offers the most widely adopted framework that provides both a vision and a description of the competencies needed for redesigning education systems to be bold and relevant for the digital age. This framework is called the ISTE Standards. Since their inception, the ISTE Standards have been adopted, adapted, or endorsed in all 50 U.S. states and the District of Columbia as well as in countries around the globe.

ISTE published the first generation of student standards in 1998, using a method that combines expert input, a review of the literature, and extensive public comment to develop performance indicators that detail elements of each standard. The early generation standards focused on ICT use; over the years, they evolved into standards that describe the type of learning students should experience and what a digital age learner should be able to do in school. The 2016 ISTE Standards (the third iteration) describe the competencies that are necessary to help students learn how to learn, to empower them to own their individual learning journey, and to help them master digital skills that will allow them to create their own future.

The ISTE Standards help educators and education leaders worldwide re-engineer schools and classrooms for digital-age learning, no matter where they are on the journey to educational technology transformation. The ISTE Standards describe this objective from the point of view of key roles in the system.

The ISTE Standards for Students empower student voice, ensuring that learning is a student-driven process. They describe the digital-age competencies every student needs to master. (figure 5.1).

Figure 5.1 ISTE Standards for Students

Source: International Society for Technology in Education.

The ISTE Standards for Educators deepen educator practice in a technology-rich classroom, promote collaboration with peers though online and professional networks, challenge traditional approaches to classroom teaching, and help educators prepare students to master digital tools to drive their own learning (figure 5.2).

Figure 5.2 ISTE Standards for Educators

Source: International Society for Technology in Education.

The ISTE Standards for Education Leaders support systemwide strategic planning to implement the ISTE Standards for Students and the ISTE Standards for Educators. They provide a framework for guiding digital age learning by targeting the knowledge and behaviors required for leaders to empower teachers and make student learning possible (figure 5.3).

Figure 5.3 ISTE Standards for Education Leaders

Source: International Society for Technology in Education.

The ISTE Standards are powerful because they describe a vision that is both systemic and transformational. By prioritizing learning over technology, they establish a vision for change that fully encompasses the instructional as well as the technological aspects of modern learning environments. They prevent the tendency to digitize poor teaching strategies and resist the urge to purchase and deploy connectivity and devices in schools before a plan is in place that articulates how they will be used to advance learning goals.

Successfully Integrating Technology in Education

The Edtech Revolution

The transformation from the factory model of mass schooling to a digital-age model requires the strategic integration of educational technology (edtech). It is not possible to scale the needed changes without it, for many reasons, including the following:

- **Edtech enables efficiencies in learning that are not otherwise possible**. They include the management and integration of curriculum content, assessments, and student work. Today's teachers juggle many responsibilities, including behavior management, special education requirements, curriculum tailoring, extracurricular responsibilities, and their own professional development. To meet these responsibilities, they need edtech to help manage as much of their workload as possible to make room for work that cannot be completed by machines, such as nurturing supportive connections with students and mentors.

- **For education to be relevant, it should help students master the digital tools for learning to learn and to improve their options in the workplace**. For example, workers in a connected information economy generally use a personal laptop, communicate at a distance with colleagues and experts, and create shared digital artifacts of their effort. Students also need to learn in 1:1 environments with personal devices (environments in which every student has a device); work collaboratively online with others, both within and outside of their physical location; and create shared digital solutions to demonstrate their mastery. If students are to be ready to meet the challenges of postsecondary education and the workforce upon graduation, their primary and secondary educational environments and experiences should bridge these worlds in important ways.

- **Digital technologies amplify personalized and student-driven learning possibilities**. For students to enjoy a learning experience that is personalized to their strengths and learning needs and relevant to career tracks of interest, they need to take ownership of their learning. It is not possible for a single teacher to mentor 25 or more students when each is on a different learning track. Even the factory model, which generally offers just two tracks—regular and advanced—can be cumbersome for teachers to direct. A personalized educational experience requires strategic use of edtech to give students opportunities to guide their own learning trajectories by setting learning goals, choosing relevant learning content, and even helping them decide how to demonstrate mastery. None of this would be feasible without a clear purpose for what and how to use digital technologies in education.

Artificial Intelligence and Machine Learning in Education

Groundbreaking developments are occurring in edtech, especially in the integration of analytics and machine learning, which empower teachers to step into a role as coaches or facilitators to personalize learning for students. The power of artificial intelligence technologies to tailor solutions to the diverse needs of students puts profound personalized learning within reach for the first time.

The U.S. National Education Technology Plan (Office of Educational Technology 2017) defines personalized learning as:

> Instruction in which the pace of learning and the instructional approach are optimized for the needs of each learner. Learning objectives, instructional approaches, and instructional content (and its sequencing) may all vary based on learner needs. In addition, learning activities are made available that are meaningful and relevant to learners, driven by their interests and often self-initiated.

Consideration of these developments offer a glimpse at the power of edtech to disrupt teaching and learning (Arnett 2016). Computerized learning applications are already able to do the following:

- Boost the efficiency and utility of assessment data and analytics, including by unifying data sets across systems and using predictive analytics that can help target at-risk students.

- Offer unprecedented opportunities in the personalization of learning, including differentiation of academic resources and curriculum that is constantly updated, curation of content resources, and adaptive learning models that can respond to student emotional reactions and demonstrated learning biases.

- Provide students with multidimensional performance data and personalized pathways for remediation, enrichment, course selection, and support in additional languages and for alter-abled learners.

- Provide teachers with up-to-the-minute dashboards describing strengths and gaps in student understanding, including comparative incorporation of big data sets, automated grading (including essay questions), and efficient management of class data sets.

• Support improved academic curriculum, including modeling for learners, customized textbooks, smart game-based learning, and immersive virtual reality and augmented reality experiences. This curriculum is particularly valuable for teachers who may lack subject matter expertise and/or industry experience in their fields.

• Facilitate a more flexible learning experience, including anytime anywhere student access to personalized content; smart formation of learning groups; and individualized learning, which frees up teacher time to support one-on-one instruction.

• Assist in integrating analytics and support for social-emotional learning into student educational plans.

• Improve systems of teacher evaluation and the identification of relevant professional development pathways.

• Provide coaching, tutoring, and academic mentoring for students based on a range of factors, including performance goals and specific learning needs (applications can even support good digital citizenship by flagging unethical behavior, such as plagiarism).

• Assist teachers in career mobility and professional development, including job matching and feedback to support course improvement.

• Enable opportunity forecasting in higher education, which would help predict what educational programs should be developed to meet the needs of the labor market as well as what courses will be in demand.

Effecting Systemic Transformation in Education

The effective use of technology ultimately hinges much more on how it is used than what is used. Many examples of edtech projects gone awry in U.S. primary and secondary systems reinforce the need for strategic edtech vision, one grounded in powerful and relevant student learning. Over decades, ISTE has provided visionary leadership for educational organizations through the ISTE Standards.

Digital learning and digital technologies offer powerful ways to redefine the school experience, and support students to learn, so that they can be prepared for the careers of today and tomorrow. The ISTE Standards can guide the strategic planning of the entire education system to create a different framework of essential conditions, necessary to make the vision a reality.

A Framework for Systemic Change

Failing to recognize that digital-age transformation is about more than technology, causes significant problems in educational systems. When you start a process of integrating digital technologies in educational institutions it is common to find situations like these:

- District leaders agree that going 1:1 is a great idea. They purchase devices only to discover that building-level Wi-Fi infrastructure is not sufficient to handle the new device load. The devices are shelved until new funding can be obtained and become obsolete before they can be used.

- Schools that have adequate Wi-Fi implement a host of new applications but without adequate teacher training on how to use them. The teachers are overwhelmed by the new system and, without proper training, fear they will fail. As a result, they resent and resist the edtech initiative, viewing it as threatening rather than empowering.

- Schools receive new laptop computers available on a mobile cart that can be moved between classrooms. Teachers who are enthusiastic about exploring new learning activities with their students find that the carts are often not available, because the computers are too often used for standardized assessment schedules, making their use for instruction inconvenient or impossible. The computers serve only as a new way to test students, sabotaging the enthusiasm and buy-in from teachers.

In each case, a lack of systemic planning on the part of the school and governing district resulted in errors in edtech implementation.

To avoid such problems and increase the likelihood of success with any edtech initiative, a strategic approach to digital learning is required. Such an approach must attend to operational facets of planning as well as an understanding of the skills and qualities that educators and leaders should have in order to lead a digital-age school. The ISTE Essential Conditions and ISTE Standards provide the frameworks needed for such systemic planning to be successful.
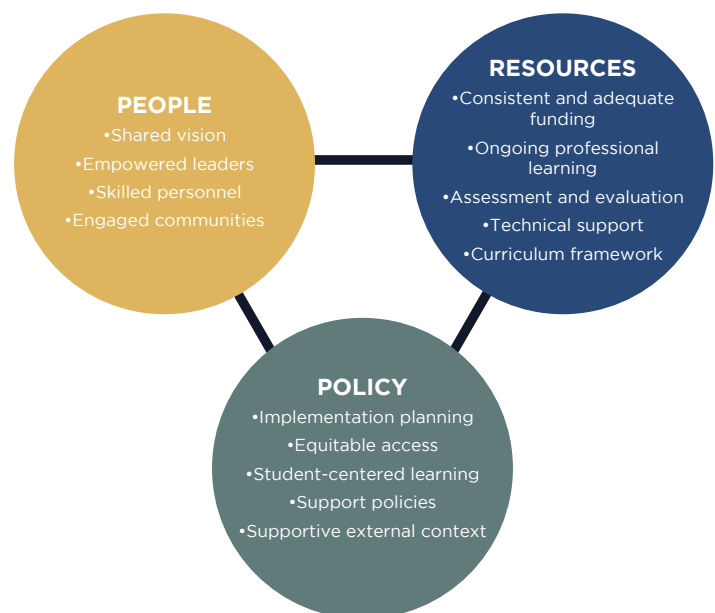
The Essential Conditions:
The Backbone for a Digital Learning Plan

The Essential Conditions are a prerequisite for the full implementation of the ISTE Standards, because it is unlikely that students will experience digital-age learning opportunities if the school system cannot effectively and comprehensively support the integration of digital technologies.

The Essential Conditions can be grouped into three categories: people, resources and policy.

- **The people category** encompasses the need for a shared vision for the use of technologies and digital learning: for leaders at every level to be empowered, for staff to be adequately trained, and for partnerships to be forged among community groups that support digital technology programs at the school.

- **The resources category** includes consistent and adequate funding for edtech initiatives, ongoing professional learning in edtech for educators and leaders, regular assessment and evaluation of the use of digital technologies, provision of technical support for students and staff, and curriculum frameworks that embrace digital-age teaching and learning goals, such as the ISTE Standards for Students.

- **The policy category** includes policies that support the digital learning practices that must be in place to empower stakeholders at all levels to leverage digital resources for improved instruction as well as an implementation plan that aligns shared goals with digital technology implementation in a coherent digital learning strategy. Policies cover equitable access to attend to the need for all educators, staff, and students to have robust and reliable connectivity and digital tools; an emphasis on student-centered learning to maintain a focus on the shift from the industrial model of education to one more suited to a digital economy; operational aspects of implementation of digital technologies in schools; and external elements, including requirements for technology funding or data privacy.

Figure 5.4 ISTE Essential Conditions

PEOPLE
•Shared vision
•Empowered leaders
•Skilled personnel
•Engaged communities

RESOURCES
•Consistent and adequate funding
•Ongoing professional learning
•Assessment and evaluation
•Technical support
•Curriculum framework

POLICY
•Implementation planning
•Equitable access
•Student-centered learning
•Support policies
•Supportive external context

Source: International Society for Technology in Education.

Historically, U.S. school districts have outlined their approach to digital learning services using a technology plan that described technical specifications related to hardware, software, and infrastructure for students, teachers, and other staff. These technology plans fail to address how edtech proposes to change teaching and learning. School leaders need to shift their thinking from a strictly technology plan to a more progressive and comprehensive digital learning plan that makes links between the types of technology tools and services available with the learning goals that fit the needs of the digital age.

The Family of ISTE Standards

While the ISTE Standards for Students are the road map for a digital-age school, the entire family of ISTE Standards provides a comprehensive guide to the skills that educators and leaders need in order to be effective in the digital age. The Standards focus on different roles in educational structures that support the individual in best meeting the needs of the learners. These roles do not function independently; the Standards were developed to go hand in hand and inform across all roles.

Figure 5.5 The Family of ISTE Standards

Source: International Society for Technology in Education.

The ISTE Standards for Educators can serve as a guide for the digital-age teacher, including the qualities teachers should exhibit. Building the following qualities into policies and practices—such as teacher hiring, professional development, and evaluation—can support a systemic approach to education transformation:

- **Learner:** Educators continually improve their practice by learning from and with others and exploring proven and promising practices that leverage technology to improve student learning.

- **Leader:** Educators seek out opportunities for leadership to support student empowerment and success and to improve learning and teaching.

- **Citizen:** Educators inspire students to contribute and responsibly participate in the digital world.

- **Collaborator:** Educators dedicate time to collaborate with both colleagues and students to improve practice, discover and share resources and ideas, and solve problems.

- **Designer:** Educators design authentic, learner-driven activities and environments that recognize and accommodate learner variability.

- **Facilitator:** Educators facilitate learning with technology to support student achievement of the ISTE Standards for Students.

- **Analyst:** Educators understand and use data to drive their instruction and support students in achieving their learning goals.

The ISTE Standards for Educators embrace the shift from teacher-driven to student-driven learning. They provide pathways for educators to leverage technology to transform teaching and learning. These standards show educators learning alongside their students, and educators leading others locally and globally.

To support this kind of educator, leaders must embrace a new model of leadership outlined by the ISTE Standards for Education Leaders. These standards reflect the shift from top-down manager to facilitating leader who leverages digital technologies to build a positive learning landscape in the classroom, school, district, and beyond. The following standards highlight how to develop a system that embraces shared leadership, trust and empowerment:

- **Equity and citizenship advocate:** Leaders use technology to increase equity, inclusion, and digital citizenship practices.

- **Visionary planner:** Leaders engage others in establishing a vision, strategic plan, and ongoing evaluation cycle for transforming learning with technology.

- **Empowering leader:** Leaders create a culture in which teachers and learners are empowered to use technology in innovative ways that enrich teaching and learning.

- **Systems designer:** Leaders build teams and systems to implement, sustain, and continually improve the use of technology to support learning.

- **Connected learner:** Leaders model and promote continuous professional learning for themselves and others.

Together, the Essential Conditions and the ISTE Standards provide a comprehensive framework for developing the operational backbone of a digital-age educational system, as well as the necessary guidance for students, educators, and leaders to be prepared for the economies of today and tomorrow.

The ways in which these standards are operationalized should be guided by a vision shared by all stakeholders, including parents, community groups, and educational boards. Everyone need not agree on every aspect of such a vision, but the vision and processes that assess progress against that vision should be clear and aligned with implementation plans at all levels. This kind of collaborative process is important to drive systemic change in educational systems. It should empower students, educators, and leaders to explore what digital-age learning looks like across diverse school contexts.

Computational Thinking in K–12 Education

Today's workforce depends on skilled workers who know how, when, and where computers and digital tools can help humans solve problems. It is difficult to find an occupation or a vocation in which workers and technology do not interact. New technical skills and competencies are necessary to prepare learners for the jobs of the present and the future.

The World Economic Forum's 2016 Future of Jobs Report indicates that a wide range of occupations will require cognitive abilities such as creativity, logical reasoning and problem sensitivity. More than half of all jobs are expected to require these cognitive abilities as part of their core skill set by 2020.

Nearly 35 percent of working adults say that they need more education and training to get ahead in their jobs or careers (Pew Research Center 2016). Emerging technologies are creating new job categories that will employ the future generation of workers (Karsten and West 2015), but only 16 percent of students graduating from high school are proficient in and interested in a career in science, technology, engineering, or math (STEM) (West 2015). Women and minorities still account for a small fraction of STEM professionals (Center for Online Education 2018). Since 2001, representation of African-Americans and Latinos in the U.S. STEM workforce has remained flat, at about 15 percent (compared with about 29 percent of the general workforce) (Bidwell 2015). Efforts to expand access to rigorous STEM learning experiences must therefore target schools serving underrepresented students and girls.

Countries around the world are creating initiatives to develop a blueprint for these new digital economies, including a commitment to prepare educators for learning, teaching, and leading in the digital age. Efforts are underway to integrate computer sciences and computational thinking (CT) in schools. These efforts aspire to equip students with the digital skill sets and competencies required for the future workforce and more active participants in the digital economy, equipping them to be creators, not merely consumers, in a world increasingly driven by technology.

ISTE's CT Competencies are designed to help all learners become computational thinkers who can harness the power of computing to innovate and solve problems.

What Is Computational Thinking?

The field of computer science encourages the development of skills, practices, and techniques that help learners work through unfamiliar problems. One of the most important examples of this is CT, a powerful approach for solving open-ended problems by drawing on principles and practices central to computer science in a way that can drive deeper learning across all subjects.

Wing (2006) identifies four pillars for bringing the idea of CT into mainstream K–12 education:

1. Decomposition: Breaking large problems into smaller, more manageable ones

2. Pattern recognition: Finding and/or matching problems or trends in data that are similar, with the hope that a solution to one will lead to a solution for another

3. Abstraction: Hiding the less important details of a problem or challenge to find a general solution that can later be tailored for specific instances

4. Algorithms: Creating a problem-solving process composed of specific steps that can be followed for future similar problems.

Researchers and educators have since modified the definition of CT using more detailed key components to help kindergarten to grade 12 (K–12) educators put these ideas into practice. In 2011, ISTE and the Computer Science Teachers Association (CSTA) collaborated with leaders to create an operational definition of CT for K–12. It includes the following:

- Formulating problems in a way that enables use of a computer and other tools to help solve them

- Logically organizing and analyzing data

- Representing data through abstractions, such as models and simulations

- Automating solutions through algorithmic thinking (a series of ordered steps)

- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources

- Generalizing and transferring this problem-solving process to a wide variety of problems.

These skills are supported and enhanced by the following dispositions or attitudes:

- Confidence in dealing with complexity

- Persistence in working with difficult problems

- Tolerance for ambiguity

- The ability to deal with open-ended problems

- The ability to communicate and work with others to achieve a common goal or solution.

CT is an approach to solving a problem that empowers the integration of digital technologies with human ideas. It does not replace an emphasis on creativity, reasoning, or critical thinking. It re-emphasizes those skills while highlighting ways to organize a problem so that computers and other technology tools and devices can help.

The skills needed to solve an equation, plan a project, or develop an outline for a writing assignment require similar competencies that students will draw upon throughout their lifetimes. CT can enhance the problem-solving skills needed to address real-world issues.

Computational thinkers are the creators, designers, and developers of the technology tools and systems that now contribute to major advances in almost every field of human understanding and endeavor. The promise of CT in K–12 education is that it can improve problem solving and critical thinking by harnessing the power of computing. It will help expand students' capacity to solve problems at a scale never before imagined.

All students should demonstrate competency in the basic skills of computer science and CT by the time they graduate from high school. The goal of educating students in CT is not to equip them for jobs in the field of computer science (although it provides such skills) but rather to prepare them to leverage CT practices and computer science concepts in their daily lives and in their future employment.

How Can Computational Thinking Be Integrated into the Curriculum?

Leaders and educators around the world have the enormous responsibility of preparing all students to harness the power of computing to succeed in their personal, academic, and professional lives. This goal is ambitious. The ISTE Standards for Educators and Computational Thinking Competencies are intended to help all educators contribute to making that goal a reality. The ISTE Standards help educators deepen their practice, promote collaboration with peers, challenge themselves to rethink traditional approaches, and prepare students to drive their own learning. The ISTE CT Competencies identify the knowledge, skills, and mindsets that educators need in order to integrate CT across K–12 content areas and with students of every age.

Computer science and CT concepts are new not only to many students but also to many educators. In order to provide a road map for educators to master these new disciplines, ISTE created the CT Competencies. These competencies are designed to outline the key areas where educators need to focus to bring CT into the classroom and lay the foundation for the broader integration of computer science as educators and students build and deepen skills. The five CT competencies for educators include the following:

1. Computational thinking (Learner): Educators continually improve their practice by developing an understanding of computational thinking and its application as a cross-curricular skill. Educators develop a working knowledge of core components of computational thinking: decomposition; gathering and analyzing data; abstraction; algorithm design; and how computing affects people and society.

2. Equity leader (Leader): All students and educators have the ability to be CT and computer science learners. Educators proactively counter stereotypes that exclude students from opportunities to excel in computing and foster an inclusive and diverse classroom culture that incorporates and values unique perspectives; builds student self-efficacy and confidence around computing; addresses varying needs and strengths; and addresses bias in interactions, design and development methods.

3. Collaborating around computing (Collaborator): Effective collaboration around computing requires educators to incorporate diverse perspectives and unique skills when developing student learning opportunities. Educators must recognize that collaboration skills must be explicitly taught in order to lead to better outcomes than individuals working independently. Educators work together to select tools and design activities and environments that facilitate these collaborations and outcomes.

4. Creativity and design (Designer): CT skills can empower students to create computational artifacts that showcase personal expression. Educators recognize that design and creativity can encourage a growth mindset and work to create meaningful computer science learning experiences and environments that inspire students to build their skills and confidence around computing in ways that reflect their interests and experiences.

5. Integrating computational thinking (Facilitator): Educators facilitate learning by integrating CT practices into the classroom. As CT is a foundational skill, educators develop every student's ability to recognize opportunities to apply it in their environment.

CT is a gateway to sparking student interest and confidence in learning computer science. Just as students use technology to deepen academic learning while building digital learning skills, teachers can integrate CT practices in their instruction to introduce computational ideas. Doing so can enhance student content knowledge and build confidence and competence in CT. By integrating CT into the classroom, educators can support students to develop problem-solving and critical-thinking skills, and empower them as computer science learners and computational thinkers.

Schools for Digital-Age Learning

It is impossible to predict how societies and economies will change over the next decades. Educators therefore need to prepare their students with highly transferable skills that will allow them to navigate change. As the focus shifts from the segmented, time-based constraints of an industrial education model to an integrated, competency-based, collaborative model that empowers students to own their own learning, master digital tools, and personalize their learning experiences to match their needs and interest, students will be preparing for a world that today's educators cannot yet imagine. This kind of change is systemic, requiring education leaders, educators, and students to take on new roles and responsibilities that better align with the demands of a shifting economy.

Digital technologies are essential for this model to succeed. But equally important is setting a shared vision for learning that embraces a view of learners as active designers and creators rather than simply passive consumers of technology. This vision will encourage students to master the new disciplines of computer science and CT, helping them become designers of artificial intelligence systems instead of seeing their professions replaced by them. Digital-age education can prepare learners to harness new economic forces, thrive in the working environment, and shape the world they inherit to match their own vision of future.

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Chapter 6

Linnar Viik

Creating Digitally Literate Students and Citizens: Estonia

Linnar Viik

With a population of just 1.3 million people, Estonia has achieved remarkable success in digital governance. Also known as e-Estonia, it is one of the most advanced digital societies in the world.

The country has embraced digitalization since the 1990s, after it restored its independence from the Soviet Union. Today Internet in Estonia is considered a social right. A secure digital identity allows residents to use thousands of public and private services online. In 2018 Estonia was ranked second in the European Union (after Finland) for its provision of digital public services (European Commission 2018). Indeed, only three public services cannot (yet) be performed online in Estonia: getting married or divorced and selling real estate (Enterprise Estonia 2019).

Continuous development and maintenance of the digital society requires local engineering and information technology (IT) competence, as well as a vibrant IT sector with an understanding of the applicability of new technologies. Deep engineering competence, strategic application, and a regular user perspective need to work together in a balanced way to build digital skills and competences. Doing so places demands on the education system, which works to achieve broader social goals.

For more than a decade, Estonian students have performed very well in general education surveys. On the 2015 Programme for International Student Assessment (PISA), Estonian 15-year-olds ranked third in the world (after Singapore and Japan) in science literacy, and were among the world's top 10 performers in reading and math literacy (OECD 2018b).

Schools have an obligation to raise digitally aware citizens who are able to effectively and safely use the Internet and public e-services and apply digital skills in their later professional lives. Digital literacy is one of eight key competences outlined in Estonia's Lifelong Learning Strategy 2020 (Ministry of Education and Research 2014) and in the national curriculum (State Gazette 2018). However, the national curriculum offers only a framework for learning outcomes, including digital competences, giving schools and teachers much freedom in terms of content, methods of learning, and the use of information and communications technology (ICT).

In 2017, 98 percent of 16- to 24-year-olds in Estonia used the Internet daily and 21 percent had programming skills (Statistics Estonia 2017). Many children in Estonia start to learn programming in primary school or even kindergarten (Information Technology Foundation for Education n.d.).

This chapter examines how Estonia designed and implemented initiatives to develop digital skills, first among young people and then among the population as a whole. The first section describes the country's vision after re-independence. The second section discuss the Tiger Leap program. The third section examines the digital focus in lifelong learning. The last section looks at the future of ICT in education and Tiger Leap as a metaphor for innovation in Estonia.

Estonia's Vision after Re-Independence

Since the restoration of independence, Estonia has followed a relatively liberal model of economic policy, influenced by the examples of Finland and Sweden. Those countries happened to be technologically advanced; Estonia copied their orientation. The process was natural because much of the foreign direct investment into Estonia came from Finland and Sweden. Nordic companies that set up in Estonia brought their technical solutions as well.

Estonia also benefitted from the fact that science education was solid during the Soviet era and the Institute of Cybernetics, founded in Tallinn in 1960, was one of the Soviet Union's leading research centers in computer science. In the early 1990s, the Republic of Estonia had access to qualified ICT experts. Indeed, many of the people who designed the digital solutions of e-Estonia had been involved with the institute.

Estonia drafted its first Estonian information society development plan in 1994, inspired largely by developments in the European Union (European Commission 1994, 1996). Parliament approved a more detailed plan ("Principles of Estonian Information Policy") in 1998. It focused on modernizing legislation, supporting the development of the private sector, fostering interactions between the state and citizens, and raising awareness about problems associated with the information society. The plan mentioned Tiger Leap as an educational program to be financed from the state budget (State Gazette 1998).

Soon after 1991, Estonia started using ICT to modernize its education system, in order to promote social development. The developments did not necessarily stem from particular strategies; more often they were sparked by decisions made at the executive level of the Ministry of Education and Culture and later integrated into strategies. The "Principles of Estonian Information Policy 2004–2006" already included the wider goals of increasing digital literacy through e-learning, increasing ICT-related research and development, and making computers available in educational institutions (Ministry of Economic Affairs and Communications 2004). ICT in education has since been an integral part of all strategic documents for the development of the information society.
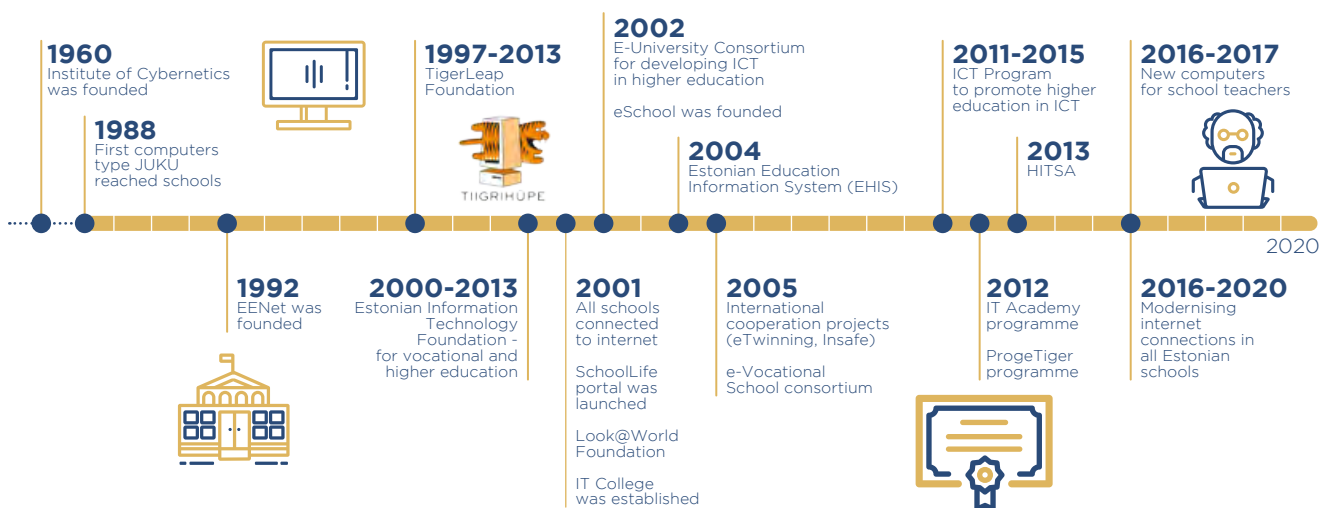
Estonia's Tiger Leap into the Future

The digital transformation process has similar goals in different countries, but the roadmaps and implementation facilities can be very different. Leapfrogging initiatives were highly centralized in some countries and widely decentralized in others; some countries built on partnerships with international donors while others collaborated with private companies. In Estonia, the initial focus was on delivering access to infrastructure and technology to schools. Vocational training, higher education, and lifelong learning followed much later.

Estonia first introduced computers in schools in 1988. Since then, it has made enormous strides in introducing ICT into the education system (figure 6.1).

Figure 6.1 Timeline of development of Estonia's education system, 1960–2020

1960 Institute of Cybernetics was founded

1988 First computers type JUKU reached schools

1992 EENet was founded

1997-2013 TigerLeap Foundation
TIIGRIHUPE

2000-2013 Estonian Information Technology Foundation - for vocational and higher education

2001 All schools connected to internet
SchoolLife portal was launched
Look@World Foundation
IT College was established

2002 E-University Consortium for developing ICT in higher education
eSchool was founded

2004 Estonian Education Information System (EHIS)

2005 International cooperation projects (eTwinning, Insafe)
e-Vocational School consortium

2011-2015 ICT Program to promote higher education in ICT

2012 IT Academy programme
ProgeTiger programme

2013 HITSA

2016-2017 New computers for school teachers

2016-2020 Modernising internet connections in all Estonian schools

2020

Source: Information Technology Foundation for Education (HITSA).

In 1993, the Education and Research Network (EENet) was established as part of the Ministry of Education and Culture, with the aim of providing universities and other science and research institutions with Internet connectivity. By 1995, 1,500 computers in more than 60 Estonian schools were connected to the Internet. The process was sporadic and had little coordination, with most of the connected schools taking their own initiative.

In an interview in February 1995, Toomas Hendrik Ilves, Estonia's ambassador to the United States, who later became the president of Estonia, called for a coordinated plan for computerizing all schools in Estonia, which he called a "tiger leap to the new century." The article ignited a broad social debate. Just a year later, President Lennart Meri initiated the Tiger Leap program. Thus was Tiger Leap—a metaphor for forward-looking vision and tangible action—created.

The aims of the Tiger Leap program were threefold: to provide schools with computers and Internet access, to provide teachers with training and exchange opportunities, and to develop native-language electronic courses to be used in general education institutions. The Tiger Leap Foundation, a nonprofit organization launched in 1997, was responsible for achieving these goals. Although it was financed largely from the state budget, it was created as a nongovernmental organization so that it could use external

funding, take part in private-public partnerships, and enjoy greater flexibility in procurement and governance processes. The initial budget of the Tiger Leap Foundation was comparable to the state IT budget. It was supplemented with cash and in-kind financing from cities and municipalities.

Basic ICT training courses was offered to nearly 4,000 teachers in 1997 and to many thousands more in the following years. Courses for teachers, which started with topics such as online information search and preparation of education materials, continue today, encompassing more advanced digital competences. Subject-specific trainings are organized largely through subject teachers' unions; general training courses on digital capacities are provided centrally. The program also centrally procured software platforms, which made it easy to standardize ICT systems in schools and minimize administrative needs.

In 2000, the Estonian Information Technology Foundation was established as a nonprofit organization with a mandate to integrate ICT into vocational and higher education. It established the Estonian IT College.

By 2001, schools all over Estonia had been provided with computers and connected to the Internet. The Tiger Leap Foundation agreed to match the financial investment made by counterparts (such as local governments).

In 2001, the Look@World foundation helped build 500 public Internet access points all over Estonia. Over the next 10 years, it conducted computer courses for 20 percent of the adult population, helping them use the Internet and public e-services.

Tiger Leap Plus, the successor program to Tiger Leap, focuses on the ICT competences of students, teachers, and educational staff. In 2001, it launched the SchoolLife education portal, which offers a cooperation and collaboration platform for teachers. The portal acts as both an information source and a repository of teaching materials.

Estonia also emphasizes e-learning and cooperation in vocational education. In 2005, 8 applied higher education institutions, 27 vocational schools, the Estonian Ministry of Education and Research, and the Estonian Information Technology Foundation established the Estonian e-Vocational School consortium, pooling forces to support digital learning in vocational education. This effort followed the cooperation example of the Estonian e-University consortium, founded in 2003 to coordinate e-learning initiatives, enhance accessibility to high-quality education, support innovation in higher education, and develop international cooperation.

Estonia launched many programs between 2006 and 2012:

- **DigiTiger** helps teachers work ICT solutions into active learning methods.

- **ScienceTiger** uses ICT resources to make science classes more interesting.

- **TigerRobotics** promotes the use of programmable robots and home lab sets in teaching and learning.

- **SewingTiger** provides sewing/embroidery machines with relevant software for craft lessons.

- **TechnoTiger** promotes the use of computer-controlled milling machines in design and technology classes.

- **AnimaTiger** uses animation to train teachers.

- **TigerMath** uses software programs in math teaching.

- **ProgeTiger** develops technological literacy, creativity, and logical thinking through programming studies (figure 6.2).

Tight cooperation developed between higher education institutions and the ICT sector, improving the quality and competitiveness of higher ICT education offered in Estonia and preparing a highly qualified labor force that meets the ever-growing needs of the ICT companies.

**Figure 6.2** ProgeTiger program focus areas for 2015–20
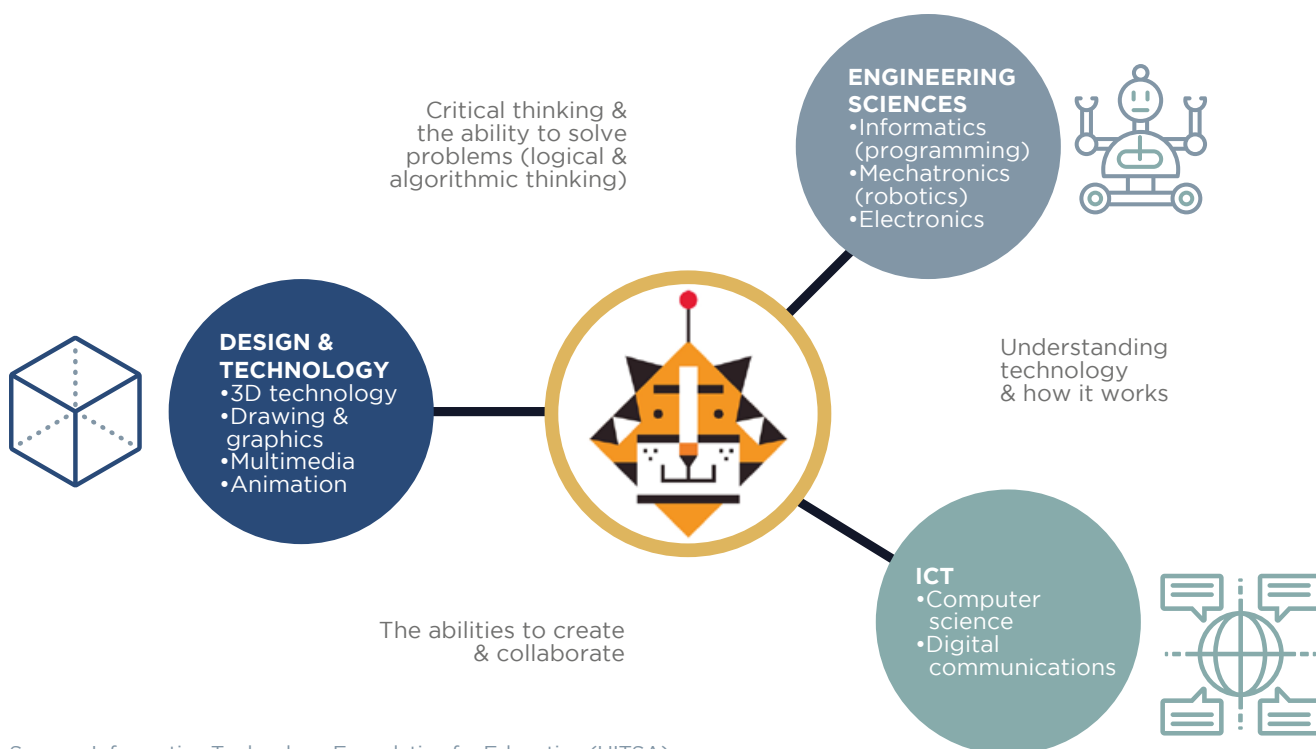
Source: Information Technology Foundation for Education (HITSA).

Since its founding, in 2013, the nonprofit Information Technology Foundation for Education (HITSA) has been responsible for incorporating ICT in education and developing the digital skills of students and students at all educational levels (figure 6.3). HITSA guides innovation and development in educational technology, takes an active part in international cooperation projects, and is in charge of exchanging and disseminating national and international best practice in the field of IT and education.

Figure 6.3 Target groups and services provided by Estonia's Information Technology Foundation for Education (HITSA)
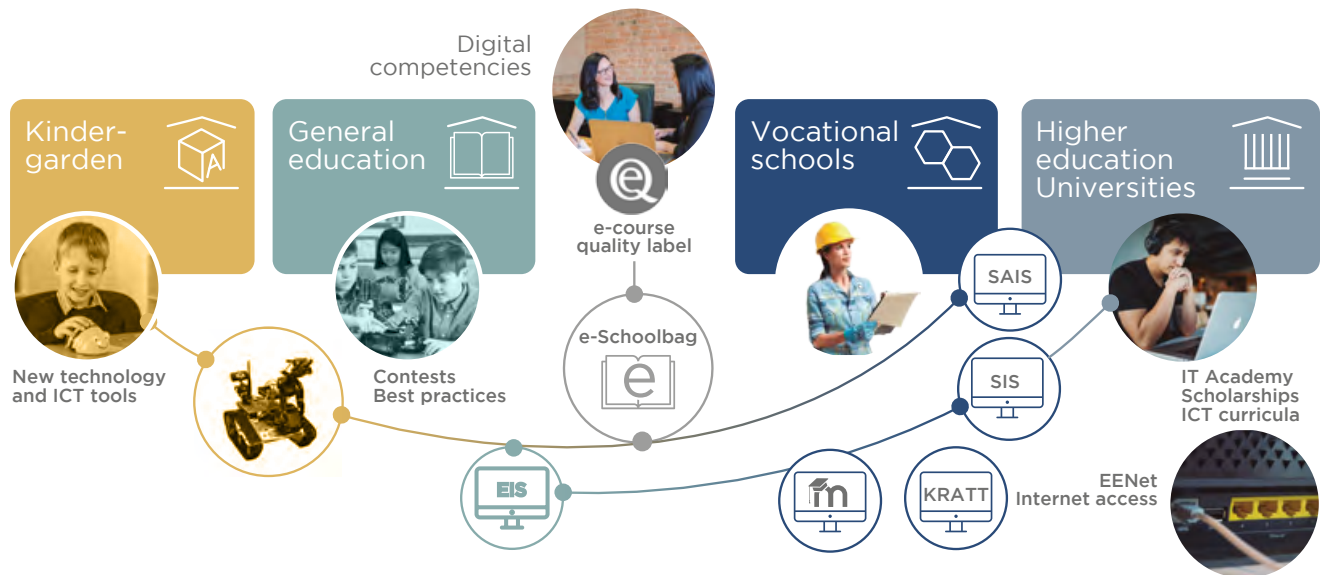
Source: Information Technology Foundation for Education (HITSA) .
Note: EIS: Examination information system; KRATT: Plagiarism detection software; m: Moodle (modular object-oriented dynamic learning environment); ÕIS: Study information system; SAIS: Admission information system

Responsibility for providing education through secondary school, including responsibility for connectivity in schools, lies largely with municipalities. HITSA develops, administers, and maintains school networks and manages their external connectivity. Its activities and initiatives include the following:

- The Innovation Center provides a self-assessment tool for evaluating educational technology skills of teachers and an environment for creating and sharing digital learning resources.

- The Development Center for Information Systems administers national education information systems.

- The Admission Information Systems (SAIS) is used for on-line application to educational institutions using a state-issued digital identity.

- The Study Information System (SIS) helps manage and automate the data of students and lecturers of higher and vocational education institutions.

HITSA also offers general assistance to educational institutions on how to use ICT in education and issues grants to support the studies of IT students and developed an online tool (the Digital Mirror Assessment) for self- and peer assessment of a school's digital maturity. Eighty-five percent of Estonians took part in the assessment in 2017, receiving scores in three dimensions:

- Digital infrastructure (1-1 computing[28], BYOD[29], wireless Internet, support)

- Pedagogical innovation (learning environment and resources, roles)

- Change management (policies, cooperation, organizational learning).

28• 1-1 computing is a teaching process in which educational institutions provide students with access to an electronic device for learning.
29• Bring your own device (BYOD) is an approach in which students are permitted to bring their own device (laptop, tablet, smartphone) to class.

In most dimensions, schools are performing at the "enrichment" level (according to the iTEC innovation maturity model[30] [European Schoolnet 2014]), meaning that technology already acts as a supporting element for differentiated learning (figure 6.4). However, teaching and learning processes have not yet been fully redesigned—the target for 2019. Goals for the future include ensuring the ubiquitous use of technology and letting learners take control of the learning process.

Figure 6.4 Results of Estonia's Digital Mirror Self-Assessment in 2017 and targets for 2019
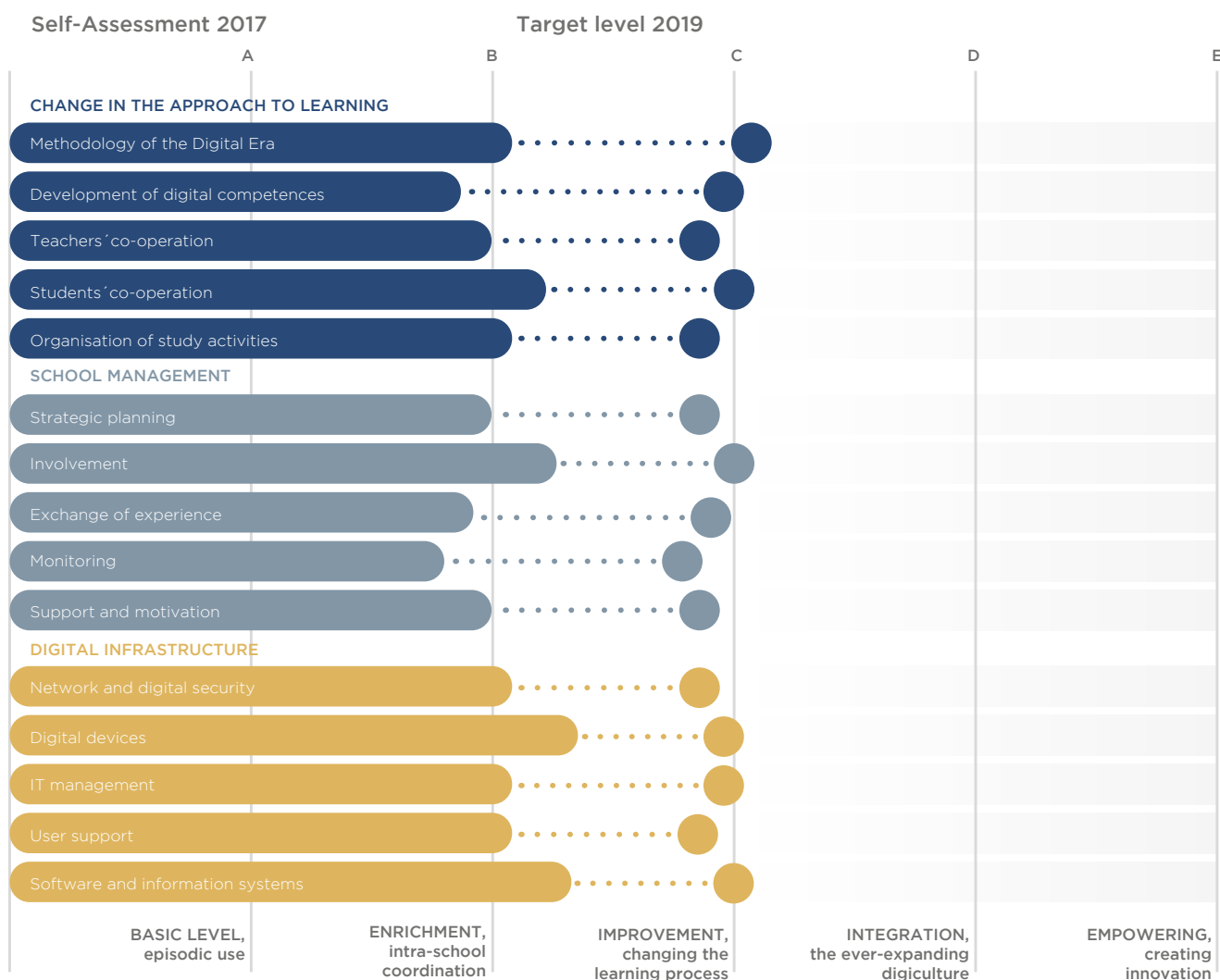
Source: Information Technology Foundation for Education (HITSA).

30• Innovative Technologies for Engaging Classrooms (iTEC) is the largest initiative ever undertaken in Europe on the design of teaching and learning in the classroom of the future. It developed a model that teachers and school administrators can use to identify how advanced or innovative their classroom or school is (see ARIADNEEU n.d.). The five maturity levels are (1) exchange (isolation of teaching and learning, with technology used as a substitute for traditional methods); (2) enrich (learner becomes user of digital technology, which improves learning and teaching practices; (3) enhance (learner is able to learn more independently and be creative, supported by technology providing new ways to learn through collaboration); (4) extend (connected technology and progress data extend learning and give learners greater control on how, what, and where they learn); and (5) empower (teachers and learners empowered to adapt and adopt new approaches and tools). For a complete description of the levels, see Future Classroom Lab (n.d.). In Estonia, the names of levels were modified for local use.

Digital Focus in Lifelong Learning

In 2014, the Ministry of Education and Research approved the Digital Focus Program, with the aim of developing a comprehensive approach to the development of digital competences and the targeted deployment of digital opportunities in the learning process, thereby supporting a changed approach to education. Digital competences are understood as "readiness to use digital technology to cope in a rapidly changing knowledge-based society when working, studying, acting and communicating as a citizen" (Ministry of Education and Research n.d.). The program integrates digital opportunities in the smart study process, focusing on meeting the needs of learners and the expectations of the labor market and providing access to a new generation of digital infrastructure for e-citizens.

Estonia's Lifelong Learning Strategy 2020 (Ministry of Education and Research 2014) states:

If the general population is better equipped with technology skills and more capable of innovation, it will help increase productivity in the economy…. What Estonia needs is a shared understanding of the direction to take when moving toward a knowledge and innovation-based society. We are successful only when we acknowledge the need to constantly learn and relearn and to be proactive and creative, so that we can cope in today's rapidly changing world. Learning and the knowledgeable application of skills must become an integral part of an active approach towards life.

The overall goal of the strategy is to provide all people in Estonia with learning opportunities that are tailored to their needs and capabilities throughout their lifespan, so that they can maximize opportunities for dignified self-actualization within society, in their work, and in their family life. The program also includes five strategic goals.

1. Incorporate a digital culture into the learning process

This goal calls for systematically incorporating new directions inspired by technological innovation into all curricula at all levels of education. The most important activities to achieve this goal include training courses; instructional materials; and general support to school boards, teachers, and learners. Educational technology and innovation is an important research field at Tallinn University, where educational technologists learn to create and support the creation of high-quality digital learning assets for educational institutions and to coordinate, develop, and support the e-learning process.

2. Support digital learning resources in schools

To better achieve the objectives set out in curricula at all educational levels, digital learning resources will be made available in the form of electronic textbooks, interactive online exercises, open educational resources, guides for teachers, and tools for online assessment. These efforts precede the eventual creation of interoperable software solutions to support the development, storage, delivery, use, and assessment of educational content in teaching and learning. The Ministry of Education and Research will take the lead in

defining quality requirements for the online learning resources, sharing best practices, and overseeing the development of training courses and instructional materials.

3. Access a modern digital infrastructure for learning

This objective has the ambitious goal of developing interoperable solutions so that the information systems and services developed and used by the state, local authorities, and schools will be accessible to all teachers and learners not only via the digital infrastructure of the educational institutions but also through personal digital devices. Achieving this goal will require developing standards, requirements, and monitoring measures for digital infrastructure as well as guaranteeing access to modern networks, presentation technologies, and personal digital devices for teachers. Several existing systems (including e-diaries, e-learning platforms and repositories, information systems for examinations, digital archives, and national educational information system) need to be integrated and adapted to the new personal digital learning environment. Where personal digital devices must be used in studies, the state will need to develop a needs-based support system for learners who do not own such devices or who have special needs because of a disability.

4. Create and implement assessment models for digital competence

The grading system needs to take the new field of digital competences into account. New assessment models are needed to evaluate the digital skills and competences of teachers, students, school board members, and adult learners. Special curricula will be developed for teacher education. A system will also need to be developed for recognizing self-acquired skills and experience.

5. Create learning opportunities for adults to acquire digital competences

Adults need access to programs that allow them to acquire and develop their abilities to use digital devices in ways that improve their quality of live and productivity at work. Estonia plans to provide training courses for them through public-private cooperation.

The Ministry of Education and Research is responsible for implementing the strategy, with contributions from other ministries, municipalities (as school owners), professional organizations, teachers, school boards, and other stakeholders. Several national programs have been compiled to implement the strategy, including general education, vocational education, higher education, adult education, teacher and school leadership education, learning resources, study and career counselling, labor market and education cooperation, and school network programs. Indicators for achieved goals include (a) increasing the share of the population 16–74 that is digitally competent from 58 percent in 2009 to 80 percent in 2020 and (b) ensuring that 100 percent of students at all levels, from primary school through tertiary education, use computers and mobile personal devices for studies every school day (Ministry of Education and Research 2014).

The Tiger Leap Metaphor Lives On

The main emphasis for the future of the Estonian education system is on consolidating competences in the fields of education, information systems, and infrastructure. Monitoring and analysis will be undertaken to evaluate the state, challenges, and development needs of the Estonian education system. They will assess the latest technological trends and translate projected needs into educational curricula at all levels, starting in kindergarten. It is important that today's children become not only skilled technology users but also creators and developers of new technologies.

Despite the decline in the number of university students (because of demographic trends), studying ICT has become more and more popular in Estonia. In 2017/18, 9 percent of all university students were studying ICT, the largest share in the Organisation for Economic Co-operation and Development (OECD 2018a). Interest and experience in IT are the most cited reasons to start ICT studies. Early experiences—such as doing something exciting with the computer, solving computer-related problems, building a computer, developing software or trying to design a computer game or web page, and even "breaking the computer"—are the most-cited examples of activities that motivated the study of ICT. However, almost a third of students drop out of ICT studies the first year, citing factors such as the lack of "suitability" of studies; personal, health, or financial reasons; or unmet expectations. (Pedaste, Tõnisson, and Altin 2017). This problem needs to be addressed.

Figure 6.5 Number and share of university students studying information and communications technology (ICT) in Estonia, 2011/12–2017/18
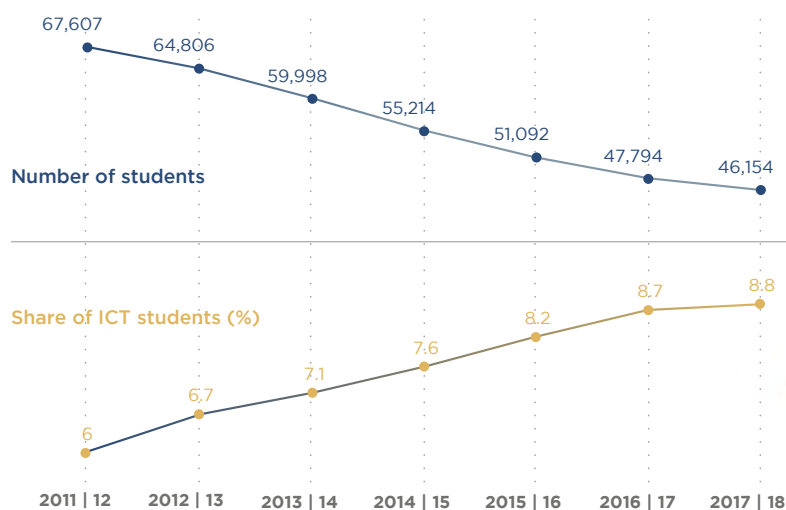
Source: Information Technology Foundation for Education (HITSA).

HITSA is responsible for providing educational institutions with IT services related to studying, teaching, and work organization. It plans to continue to consolidate basic ICT services under the Ministry of Education and Research, a cost-effective and secure way of guaranteeing the functioning and development of IT infrastructure. Work is also ongoing regarding modernizing the digital infrastructure of general education schools. Furnishing them with the best wireless and local network connections will raise the competitiveness of the Estonian education system and help maintain the e-Estonia reputation.

Tiger Leap provided all students in Estonia, regardless of their social status or location, with similar competences and access to the Internet. Sharing information, valuing digital assets, using digital technologies in problem solving, and establishing a high trust level in digital technologies have not only built technical skills in Estonia's students, they have also instilled them with shared values. Indeed, the success of Tiger Leap is manifested not only in the vibrant Estonian digital start-up scene but also in the broader social impact of the Tiger Leap generation. The most recent prime ministers, high-ranking civil servants, and business managers are all from the Tiger Leap generation.

The phrase tiger leap is still used today, but it is no longer associated only with innovation and digitalization of the education system. It has evolved into a broader metaphor, a meme that reflects forward-looking vision, an aspiration of Estonian society, and goals that initially seem beyond reach but still need to be pursued. policymakers, the media, and citizens wonder when Estonia will adopt a tiger leap in other sectors, such as agriculture, forestry, and road administration.

Many social studies and opinion leaders rank Tiger Leap among the top 10 most important historic activities and initiatives in Estonia during the last few decades. Even in 2019, when political parties propose their programs for upcoming parliamentary elections, the metaphor of Tiger Leap is on their agenda. Parties call for Tiger Leap 2.0 and promise to reignite Tiger Leap. Tiger Leap has evolved into a brand.

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PART
04

Transforming
Education

Chapter 7

Mercedes Mateo and Changha Lee

Technology with and without Transformation

Mercedes Mateo Diaz and Changha Lee

Children and youth are growing up in a world in transformation. They learn content without knowing which jobs they are preparing for—because many of these jobs are unknown today. They will have to change occupations more often than ever before. Robots will replace them in many occupations, and humanoids will be their companions at work and maybe at home. In the midst of this transformation, Covid-19 has caused massive disruption, affecting every aspect of life, including education.

Before the crisis, there was much debate about the role of technology in education. Today, even if the debate is still ongoing, the need to move abruptly into distance education has made learning heavily dependent on the level and quality of EdTech system readiness. Before the crisis, innovation and digital transformation were rapidly changing the ecosystem, but most education systems continued to move at a pace that did not keep up with the pace of advancements in technology. Only some systems were able to overcome that inertia. When the crisis hit, those systems were ready to quickly transition and keep learning going even if schools were closed. How were these systems able to anticipate, transform, and adapt to a world in motion? What did they do differently? How did they succeed not just at integrating technology but also at producing massive improvements in student learning outcomes? What can other countries learn from their experiences?

This book is about trial and error, about stories of success that sometimes emerged from failures that forced policymakers to readjust. It is also a call for action for countries in the Latin America and the Caribbean (LAC) region. Countries that are rethinking their education and training systems today can learn from the experiences and mistakes of those that have done it before. To help them do so, this chapter highlights the critical issues reformers will encounter and identifies the main trade-offs for policymakers introducing new technologies into the classrooms.

What Technology Can Do For Education

Countries can implement technology without fundamentally transforming their vision for education. They can drop technology in the classroom without clear learning objectives and without teachers changing their classroom practices. Nothing—or not much—will happen. Alternatively, countries can transform their education systems, without making the whole reform around or about technology.

The cases presented in this report illustrate that countries can follow different and overlapping paths and sequences, timeframes, and approaches. Early reforms in the United States focused tightly on the specifications of infrastructure and devices in schools; they later evolved into offering learning opportunities for students that are personalized and skill based. Korea greatly expanded connectivity and devices to all schools at the inception of its reform. It later moved onto teacher training and curriculum development, eventually arriving at the current stage of adaptive learning and coding education. In the mid-1990s, Finland put information and communications technology (ICT) infrastructure in place and heavily invested in teacher training. Harnessing technology, education reform in Finland has been largely skill-based. The focus transitioned from digital skills (in the 2000s) to transversal skills (in the 2010s).

Estonia implemented an education reform shortly after independence, in the mid-1990s. It introduced ICT infrastructure, e-learning courses, and teacher training simultaneously. Technology was at the core of its education reform. Later reforms made coding education compulsory beginning in first grade and recognized digital skills as the foundation of lifelong learning.

Uruguay embarked on education reform much later than the other three countries. Since 2007, it has focused first on closing the digital divide, expanding connectivity and devices to all schools, only later investing heavily in developing content and teacher training. It now focuses on transversal skills and coding education.

The time spent on reforms also varied from country to country (figure 7.1). It has been more than four decades since Finland and Korea started transforming their systems, whereas Uruguay has been reforming for only about a decade.

Figure 7.1 Timeline and stages of reform in Uruguay, Estonia, Korea, and Finland, 1970–2019

YEARS

Uruguay

Focus on connectivity and devices (CEIBAL Phase 1)

Focus on teacher training (CEIBAL Phase 2)

Focus on 21st century skills and coding (CEIBAL Phase 3)

12

Estonia

Focus on infrastructure, teacher training, and e-learning materials (TigerLeap)

Focus on digital skills of students and teachers (TigerLeap Plus)

Coding instruction made compulsory beginning in grade 1 (ProgeTiger)

Technology infused into lifelong learning (Digital Focus)

22

Korea

Computer education introduced at all levels of education

Focus on infrastructure (MP1)

Focus on online platform development (MP2)

Revised curriculum and digital textbooks introduced (MP3)

Focus on adaptive learning and 21st century skills (MP4)

Coding instruction made compulsory beginning in grade 5 (MP5)

Humanistic and future-oriented approach to education adopted (MP6)

45

Finland

Computers introduced in education

Reform introducing ICT-based learning, with emphasis on teacher training, adopted

Reform focused on developing knowledge and skills for the information society adopted

Reform focused on developing transversal skills, including ICT competence, adopted

47

1972 1974 1985 1987 1990 1992 1995 1996 1997 2001 2002 2004 2005 2006 2007 2010 2011 2012 2014 2015 2016 2017 2018 2019

There are also some differences in approach. Korea centered it reform on technology. Its masterplans were guided by the level of connectivity and the distribution of devices; they evolved as advanced technology became available in the classroom. For example, the first two masterplans allocated resources to distributing more computers to schools,[31] whereas the key activity in the third and fourth masterplans was the introduction of digital textbooks viewed on tablets. During the fifth masterplan, coding robots were widely distributed, as coding education became compulsory in primary schools. Teacher training and curriculum development corresponded to the introduction of new technology and were updated periodically.

[31] The number of students per computer in elementary school in Korea was drastically reduced, from 26 to 7, between 1996 and 2005 (KERIS 2009).

In contrast, the guiding focus of the reforms in Finland has been skill acquisition and teacher training. The education reform in 1995, for example, highlighted digital skills for the information society and invested heavily in the pre- and in-service training of teachers to ensure quality teaching in those skills. Under this approach, technology is actively incorporated, but it plays an assistive and secondary role[32] Rather, teachers are considered the protagonists and leveraged as agents of change during the reform process.

Estonia and Uruguay executed reforms decades after Korea and Finland did, but they quickly caught up to arrive at the current stage of personalized and skill-based learning. Leveraging the advanced science and technology inherited from the Soviet Union, Estonia began actively reforming education shortly after its independence. Its model, TigerLeap, resembled the models of Korea or Finland. It featured activities similar to Korea's first two masterplans but was carried out in a more simultaneous and accelerated way (over 4 years in Estonia versus 10 years in Korea). TigerLeap Plus mimicked the skills approach promoted in Finland and tapped into the digital skills of students and teachers. These similarities notwithstanding, education reform in Estonia is fundamentally different, given its close coordination with the centralized digital agenda e-Estonia.[33] This alignment is stronger than in other countries, as technology has permeated almost all functions of life in Estonia.[34] For example, the most recent reform, Digital Focus, promotes digital skills at all ages and acknowledges it as the foundation of lifelong learning.

Uruguay was able to do in a decade what other countries took four decades to achieve. Capitalizing on experiences abroad, Uruguay chose the elements that made most sense and tailored them to its own needs. Like Korea, it clearly defined stages of execution (infrastructure, teacher training, curriculum development, skill-based learning); like Estonia, it invested in infrastructure heavily. Like Finland, it focused its second phase on the professional development of teachers.

Still, the Uruguayan model is country specific, given its strong approach to social equity. The one laptop per child (OLPC) policy was implemented to close the digital divide, and innovative programs (such as videoconferencing for English learning) were scaled up to expand access to quality learning. At every stage, the underlying theme has been social inclusion.

Despite each country's distinctive approach, some commonalities can be found across countries. First, although the visions set by each country were different, all four countries incorporated technology into education as part of a larger strategy to achieve socioeconomic growth. The relative weights of the social and the economic components of the strategy differed, with Finland and Uruguay placing more emphasis on social development and Korea and Estonia focusing more on economic growth. Second, all four countries carefully considered who oversaw the reform and how it was orchestrated. Based on the context, each country came up with an implementation strategy and a corresponding institutional design to support its execution. Third, all

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32• Three of the five objectives of Finland's 1995 education reform had to do with teacher training; only one covered infrastructure.

33• e-Estonia refers to a movement by the government to facilitate citizen interactions with the state through the use of electronic solutions. For information, visit https://e-estonia.com/.

34• All public services except marriages, divorces, and real estate sales can be performed online in Estonia (Enterprise Estonia 2019).

countries assumed a sequential approach, but the focus of the reform (for example, technology versus skills) differed. Although the focuses differed, all countries started investing heavily in technological infrastructure (connectivity and devices) and combined or sequenced those investments with teacher training and curriculum development. The last stage is to achieve a personalized and skill-based learning environment.

Investment in technology provided a rich environment for pedagogy to settle in, innovate, and thrive. Countries often started with learning about technology (the digital skills necessary to use technology) and evolved into learning with technology, mainstreaming its use into traditional subjects (math, reading, science) and transversal skills (including computational thinking).

Technology can have a significant impact on a number of elements and processes. Some will not happen at all without EdTech; others will be more inefficient, unsustainable, unscalable, or take longer.
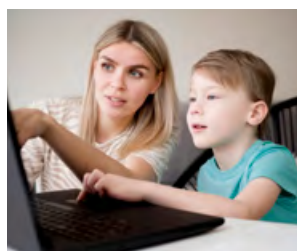
Technology can:

1. Narrow the digital divide. Increased connectivity and devices in the classroom can level the playing field for students regardless of their family background. In contexts like Covid-19, in which learning moves to home, countries should consider additional measures to close the digital divide, such as providing free data plans for education platforms and individual digital devices for students. Given this equity approach to learning and the foundational role technology plays in education reforms, the installation of ICT infrastructure should be prioritized (it frequently occurs at the inception stage)[35] Technology brings ubiquity to learning. Korea's first masterplan intended to establish an information technology (IT) ecosystem in which anyone from anywhere and at any time can access learning.

2. Diversify tools for learning. Technology can help students diversify their learning tools. The updated digital textbook in Korea is accessed by tablet. It incorporates augmented reality and gamification to teach social studies and science in elementary schools.

3. Provide personalized learning. Technology promises customization of learning based on the individual needs and interests of students. Incorporating technology-based adaptive learning, students can learn at the pace that is right for them, with the right resources and mentoring to assist them at the right moments (see more on personalized learning in chapter 5). The Smart Learning project in Helsinki incorporates digital analytics to allow learning to progress at an individual pace.

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[35] Uruguay for example closed the digital gap for students between the age 6 and 13. In 2017, their access to computer ranged from 90 percent to 99 percent across all income groups (see chapter 4 for more information).

4. Better develop traditional and transversal skills. Leveraging technology, students can effectively develop traditional skills (literacy and numeracy) as well as transversal skills, which have become increasingly relevant in the 21st century. In Uruguay, for example, where there is a shortage of proficient English teachers, students learn from remote teachers, connecting by videoconference from other parts of Uruguay, the Philippines, and the United Kingdom (Marconi et al. 2017). Applications also support good digital citizenship skills, by flagging unethical behavior of students, such as plagiarism. Computational thinking skills are also gaining more attention as a core part of 21st century skills. All four countries emphasized coding education in their most recent reforms, with Estonia and Korea making it compulsory in elementary schools.

5. Strengthen teachers' professional development. Teachers in Korea access an online teacher training portal to develop digital skills, seek job coaching, and consult on career mobility. The online platform Estonia developed during TigerLeap Plus provides a space for teachers to search information, store and share teaching materials and lesson plans, and communicate with fellow teachers, creating a community for a collaborative professional development.

6. Improve efficiency in school and classroom management. Technology adds efficiency to day-to-day transactional activities (grading, taking attendance, communicating with parents, etc.) in classrooms and schools. It frees up time spent on repetitive and tedious tasks, allowing teachers to support one-on-one coaching and academic mentoring of students. Korea's National Education Information System (NEIS), for example, which is open to all members of the school community (students, parents, teachers, and school staff) transferred all administrative tasks and information online, reducing the amount of paperwork and making the paperwork that remained more effective.
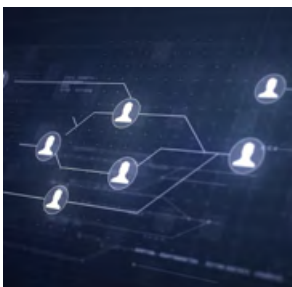
7. Gather data and generate information. Technology facilitates the gathering of big data and informs immediate actions and effective policymaking. In the classroom, a real-time dashboard in the learning management system can help teachers identify strengths and gaps in student understanding. Aggregating the information at the school level allows school leaders to design and implement appropriate responses to target at-risk students. The data can also predict and forecast skill development at the national level and inform policymaking for a smooth supply of human capital in the labor market.

What Technology Cannot Do for Education

If technology is to benefit education, the other pieces of the reform must also be in place, in order to create an enabling environment for the transformation of education and the improvement in student learning and skill development. Technology alone cannot change the direction and break education away from doing business as usual if the reform is not guided by a vision, if the system is too rigid to overcome the inertia, if teachers are not appropriately trained, and if the institutional architecture does not correspond to the implementation strategy.
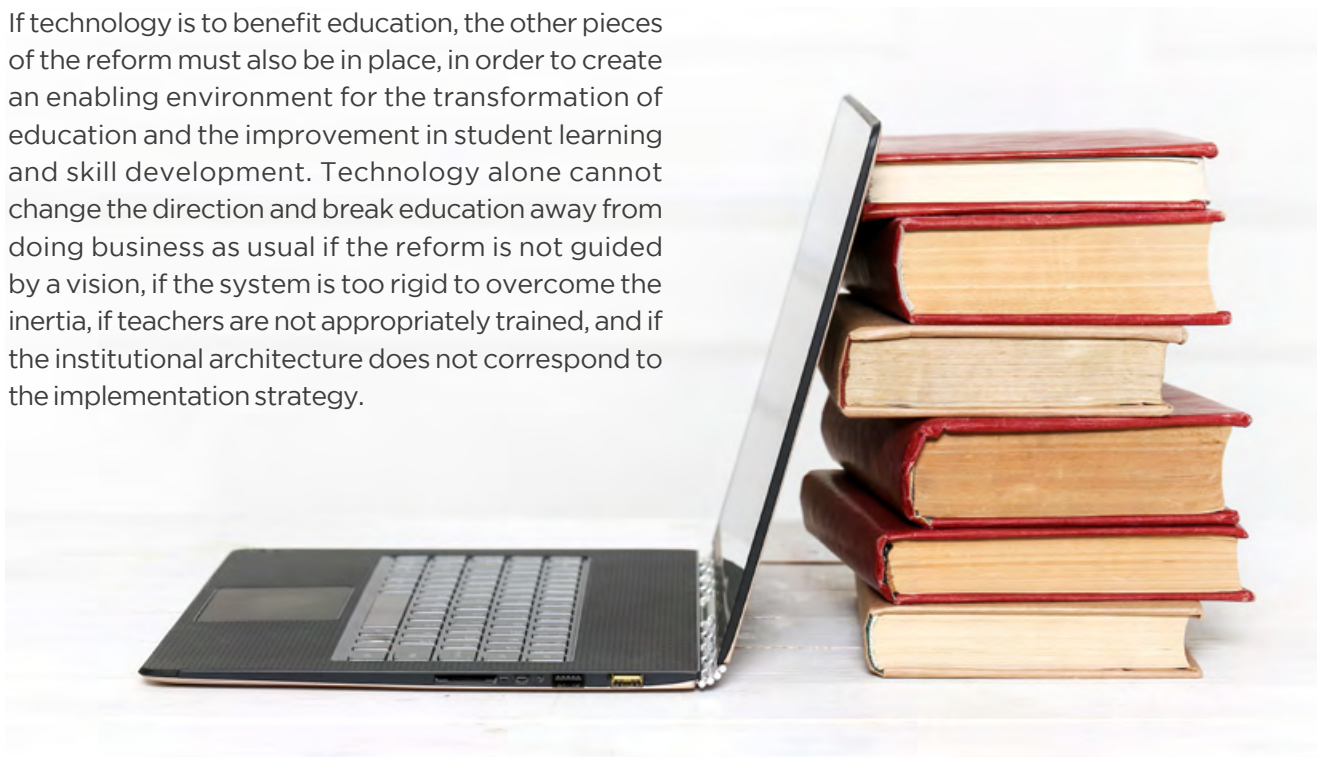
The International Society for Technology in Education (ISTE) Essential Condition allows countries to understand and gauge the type of effort, systemic change, and prerequisites needed if the reform is to produce meaningful change. It groups action items into three categories: people, resources, and policy. Technology or technical support represents just one item (under resources) among the 14 action items suggested.[36] All of items need to be adapted to take account of the contexts in which reforms are implemented; no reform can be simply exported to another context. There is no one size fits all to reform policies.

Transforming education is a communal, participatory, and formative work that necessitates human effort but can be enhanced by technology. It is communal and participatory in that it requires close coordination by all members of society, including government officials, who set the overarching framework (the vision, implementation strategy, institutional architecture, etc.); headteachers, who manage the reform at the school level; teachers, who are empowered and participate in the training and translate it to classroom practices; students, who are leaders of their own learning processes; and parents, who support them. It is also a formative work, in that reforms are often sequential, with lesson learned from previous cycles feeding into and improving the following phases. In all aspects of the reform process, technology such as big data, data analytics, and artificial intelligence greatly improves the quality of human interaction.

Lessons learned from the case study countries point to enabling factors for technology to work in an education reform.

36• See figure 5.4 in chapter 5 for the composition of ISTE Essential Conditions.

Technology alone cannot:

1. Generate a shared vision. No two countries are guided by the same vision, because visions are crafted and drawn from specific contexts. Leaders must carefully analyze their country's strengths and weaknesses, define where they want to move the country, and set specific goals so that all actions point in the same direction. Vision has to be ambitious, it has to inspire while being realistic, and it needs to permeate all actors. Finland's current vision is to capitalize on the practical application of technology. Its minister of finance, Mika Lintilä, noted that in a global economy led by technology powerhouses like China and the United States, Finland's niche lies in practical application—giving its student the skills to take advantage of the newest technology (Barua 2019).

2. Achieve social equity and inclusion. Unless equity and inclusion are core to the strategy, technology will not improve them. Indeed, it can even increase differences in access and learning. Uruguay set a vision in which equity and inclusion were core to what it wanted to achieve in the different phases.[37] The first objective was to close the digital divide. To do so, it first expanded connectivity and devices in schools in rural Uruguay; later it increased access to these resources in Montevideo and Canelones (Ferrando et al. 2011). Targeting lower-income groups was also an essential part of the strategy in Korea, where large learning differences between low- and high-income students were connected to wide differences in education spending. The Cyber Home Learning System, introduced under the second masterplan, provided open access to quality learning materials and tutorial support, with the aim of bridging the learning divide created by private tutoring in Korea. Equity and inclusion were also core principles of the education reform in Finland. By bringing quality education to all students, it achieved massive improvements in learning that placed the country among the top ranked on international tests such as the Programme for International Student Assessment (PISA).

3. Improve learning. Programs that simply provide computers and Internet connectivity without doing anything else do not seem to improve academic outcomes. Such programs do increase computer usage and computer proficiency, however—a not insignificant achievement given the growing need for digital skills in increasingly technology-based societies (J-PAL 2019).

4. Make implementation successful. There is no one size fits all strategy in education reform. Checklists of action items (such as the ISTE Essential Conditions) can provide guidance, but countries must design and execute their own plans. The case study countries had largely similar views of what to do, but their approaches to how to do it were quite different. When it came to providing infrastructure, teacher training, and e-learning materials, Korea and Uruguay took a step-by-step approach, whereas Estonia carried out the reforms simultaneously. Finland implemented its reform sequentially but organized each stage based on skills. The Finnish approach to defining stages based on skills was unique until the 2000s. It became more common in the 2010s, when other countries began to design their reforms around transversal skills.

37• Uruguay recognizes access to technology as a human right. The government ensures that all children have the right to have technology at their fingertips and the right to connectivity and access to the Internet. It deems access to the Internet in school as important as access to electricity and running water (Brechner 2019).

5. Change the institutional architecture. Institutional design is key to the success of any reform. Technology does not determine it. As part of the implementation strategy (the how), each of the case study countries put a governmental entity (the who) in charge of the reform. Korea established the Korea Education and Research Information Service (KERIS), under the Ministry of Education, to implement its ICT masterplans, but it made it quasi-governmental and independent, in order to facilitate the influx of external experts necessary to transform the education system. In Finland the National Agency for Education is in charge of implementing all reform policies, which provides continuity and consistency and allowed technology to be in sync with other components, such as teacher training and curriculum development.[38] The TigerLeap Foundation in Estonia was strategically established as an NGO to capitalize on public-private partnerships and enjoy flexibility in the governance and procurement processes, although a majority of funding came from the state. Conectividad Educativa de Informática Básica para el Aprendizaje en Línea (CEIBAL), in Uruguay, was created by an executive decree, which evolved over time. An intergovernmental council that includes the president of Uruguay oversees its activities.

6. Empower teachers to become agents of change. Teachers will not change their instruction and practices just because a new element is dropped into the classroom. They need to understand the new opportunities technology opens up, share the conviction that technology can make their work more efficient and effective, and be willing to develop new skills in order to embed new tools into their teaching. Without this process of empowerment, technology will not generate meaningful change. On the contrary, it could generate insecurity, discomfort, and confrontation between teachers and policymakers. Communication and teacher training are key in this process. The Finnish National Agency for Education included teachers and headteachers (as well as students) as board members and approached the reform as a shared effort involving the entire education community. The agency remains close to the school community and makes frequent visits, not to control but to collect feedback to inform subsequent reform phases. In Finland teachers are agents of change and the protagonists of reform, along with students.

7. Provide support and ensure students' well-being. With the rising uncertainty and rapid changes in the 21st century (including automation, climate change, aging, migration, and now Covid-19), students need more socio-emotional support than ever from the education community. Technology alone cannot provide counseling and mentoring to help students achieve individual and social well-being. When uncontrolled, technology can be a threat to that well-being—if, for example, students indiscriminately use videogames or the content available on different online platforms or are bullied on social media. Technology can free up the time teachers spend on basic knowledge transmission and administrative tasks, allowing them to devote more time to providing attention and support to their students as mentors, listeners, and the people to turn to when students feel insecure or lost. If these needs are to be addressed, the focus on student well-being needs to be explicit and included in the implementation strategy.

38• The unique aspect in Finland is a two-tiered institutional design in which the Ministry of Education is in charge of legislation and funding, and the Finnish National Agency for Education is in charge of implementing education policies. This structure allows for education to transcend a political commitment by a particular administration so that policies are implemented over the long term, focusing on practices relevant in the classroom (for more information, see chapter 2).

What Are the Trade-Offs?

Technology provides an opportunity to reach more students in a much faster way. For this reason, it is often associated with the promises of transforming education systems (Winthrop, Barton, and McGivney 2018) and revolutionizing learning. Technology is an ally of education, because it helps youth develop the skills they need to progress and actively contribute to building prosperous societies. Technology allows educators to imagine new, replicable, low-cost solutions that can be scaled; technology can also drive policymakers to think and operate in an efficiency mode, however.

Some points of tension to consider when incorporating technology into learning include the following:

1. Technology can open up new possibilities, but it can also limit how and what students learn. Learning is also about taking the time to reflect, doing so in a creative way, even if it may take more time. To learn and create, it is sometimes important to waste time. There are many things we can do fast by taking a shortcut, but learning is about trial and error, about making mistakes and striving to correct them along the way. This experimental process is as important as—or at times more important than—simply getting a final grade on an exam. Students may be able to pass tests without understanding the logic of the problems they solve. If this is the case, they will be unable to identify patterns and solve more advanced problems.

2. Technology can provide support for learning, but it can also have a negative impact on some students, particularly students needing the most help. Technology allows teachers to personalize learning and to reach larger numbers of students at a lower cost. But it can have negative impacts on learning. In terms of reading skills, three studies demonstrate that although students report that they prefer reading on screens, when the text was longer than one page, their reading skills were worse than when they read on paper (Alexander and Singer Trakhman 2017). The studies also found worse learning outcomes for science. The test results of 15-year-old students on the PISA show that students who reported using the Internet for many hours a day performed worse students who used it less intensively (Echazarra 2018). A growing body of evidence also indicates that it is the best students who profit the most from online education programs; disadvantaged students lag in terms of learning (Dynarski 2018). It is precisely these students who most need skilled classroom teachers. The expansion of EdTech needs to go hand in hand with improvements in the curriculum and learning materials (Bettinger and Loeb 2017), so that they better respond to the individual needs of each student.

3. Technology may increase the intrinsic motivation of students, but it can also negatively affect their socio-emotional development and mental health. It is unclear how technology can contribute to the development of socio-emotional skills or the extent to which it can replace human interaction without compromising the quality of development of those skills or generating negative effects. Differences in learning between high- and low-income children begin at an early age, when interactions between children and adults are most crucial (Fischer 2013). Although demand for socio-emotional skills is on the rise, teenagers spend more time alone with their screens and digital gadgets; go out less; and, although they are avid social media consumers, are increasingly isolated socially (Twenge 2017; Brooks 2018). And they are aware of it. Students themselves admit that having Internet access during class can be a distraction. Use of the Internet is often associated not only with poor academic performances but also with tardiness, low educational aspirations, low life satisfaction, and symptoms of isolation and depression in adolescents (Echazarra 2018).

4. Technology can facilitate large-scale testing, but it can also limit the ability to capture other important aspects of learning. Software on the market does an excellent job of measuring cognitive learning outcome of students; using it is the fastest and least expensive way to evaluate what a student has learned. Universities with the fewest resources and large shares of low-income students are more likely than more selective universities to use these measurements, because they are short, quantifiable, and standardized (Worthen 2018). But such tests are not capable of capturing critical thinking and other skills that the labor market seeks and rewards.

How to Implement Reforms:
The Basics

Technology and an enabling environment for education reform can produce substantial improvements in student learning and skill development. Making use of the cumulative and distilled knowledge that trailblazing countries acquired over decades can save LAC countries time and maximize their limited resources by learning from other countries' experience.

Figure 7.2 summarizes the basics of implementing a reform that transforms education. It shows that technology is only one piece of the puzzle.

Figure 7.2 Checklist of implementation basics for an EdTech reform

Connectivity and closing the digital divide

Vision

Address ethical issues

Implementation strategy and institutional architecture

Collect evidence for policy-making

QUALITY LEARNING FOR ALL IN AND OUT OF SCHOOL

Buy-in from all stakeholders

Empower teachers

Change what students learn

Change how students learn

Successful reform requires the following actions:

1. Make the reform about learning. Every piece of the reform should keep learning at the center. Technology is just a means to an end. Reform must be shaped around skills and how schools develop them for all individuals. Without such an approach, technology may exacerbate the learning divide.

2. Invest in connectivity and narrow the digital divide. Establishing connectivity and ICT infrastructure (devices) in schools is key to bridging the digital divide. Without technology, there is no transformation. As Miguel Brechner, the president of Plan CEIBAL, notes "Having connectivity and technological infrastructure in schools is like having water and electricity. No one questions their value or need" (Brechner 2019).

3. Base the reform on a vision. A vision is a goal that is contextualized and realistic. It is achieved over the long run, not under a particular administration. Evarist Bartolo, the former minister of education and employment in Malta, notes that "we must discuss not where technology is taking us but where we are taking the technology" (eTwinning Europe 2018).

4. Define an implementation strategy and institutional architecture. After setting the national vision, policymakers need to design a clear execution strategy, adapted to the country's realities, and define an institutional architecture that can efficiently and effectively carry out the plan within the politically possible. A clear execution strategy along with corresponding architecture allowed Uruguay's Plan CEIBAL to execute in one decade what other countries did in four.

5. Ensure buy-in from all stakeholders in the education system. Reforms, especially visions, are often crafted through a top-down process. Successful reform requires effort by all members of the education community—policymakers, school management, teachers, and parents, as well as the private sector and civil society organizations. The spirit of the reform and the efforts required to turn it into transformative change in education need to permeate every stakeholder, so that they translate into improvements in learning.

6. Change how students learn, by updating pedagogical practices in traditional subjects. Advancements in technology such as machine learning and gamification can help students better engage in the learning process and offer new venues for personalized learning. Evidence on the impact of gamification, for example, indicates that it can improve student learning outcomes in traditional subjects (Mateo and Becerra 2019).

7. Change what students learn, by updating the curriculum based on the skills relevant for the 21st century. The new curriculum needs to be interdisciplinary, reflecting the real world; updated with new subjects, such as coding; and centered on 21st century skills, which will help students learn to learn, empower them to take ownership in learning, develop digital skills and socioemotional skills, and learn throughout their lifetimes. [39]

39• Twenty-first century skills are the skills that are essential for the development of each individual; are necessary to navigate healthy, productive and happy lives; are reusable, because they are widely transferable from one area of life to another; and are not associated with a specific job, task, sector, discipline, or occupation. For a full list of 21st century skills, see Mateo Dias (2019, p. 23).

8. Empower teachers to become agents of change. Reformers must offer opportunities for teachers to develop professionally. They must provide incentives for teachers to continue learning and improving on the job. The role of the teacher should be less that of an instructor and more that of an analyst, designer, collaborator, learner, facilitator, leader, and citizen (see the ISTE Standards for Educators).

9. Monitor and evaluate progress, and collect evidence for policymaking. Although classrooms have become crowded with devices, there is little evidence about what works best in learning. Plugged or unplugged? Online, offline, or blended? More evidence needs to be collected to improve policymaking on the effective use of technology in teaching and learning.

10. Address ethical issues. Ethical issues include the use of data on students' personal and academic information; respect and safety in the cyberspace (cyberbullying, inappropriate contents, online predators, etc.); and intellectual property questions about the ownership of knowledge.

All of the countries covered in this book invested in connectivity, set a vision, defined an implementation and institutional strategy, updated the curriculum, trained teachers, and tackled equity through technology. However, many faced difficulty obtaining buy-in from stakeholders, particularly tapping into the teaching force by investing in and empowering them, collecting evidence from the executed plans, and addressing ethical issues in the cyberspace.

Beyond Covid-19: What Will Be the New Normal in Education?

COVID-19 has accelerated the disruption in a world already in transformation. After a traumatic experience with remote learning in most countries, no one can now imagine a new normal without technology. The crisis is redefining the future of learning, shifting priorities in ways that will help students become leaders, not followers, of their own learning trajectories.

A 21st century education requires the capacity to reach and make sure everyone keeps learning, whatever the circumstances. Countries like Estonia, Finland, and Korea spent several decades implementing their reforms. Given the crisis, LAC will have to go the "Uruguayan route," rapidly achieving change in years rather than decades. Today in Uruguay 98 percent of students have access to a computer at home for free; it is the only country in the region that had the digital conditions to navigate the crisis, bringing education to the most vulnerable students under unprecedented conditions. Educators must ensure that they are ready for a future that is already happening. Technology must be part of the solution, but it cannot end up replicating or exacerbating the learning divide.

Given the difficulty the region has had providing education during the emergency, the crisis has not been a great leveler. It highlights the pervasive socio-economic differences already existing among students and the inequality in access to technology, connectivity, and digital resources. During the shutdown, most of the region's students—110 million of students—were outside their classrooms (IDB 2020). Only some of them kept learning, because many lacked access to infrastructure, platforms, parents who could support their learning, and teachers prepared to learn and teach remotely.

Policymakers now need to reimagine what the new normal will look like. They need to determine how education systems can reinvent themselves, because people cannot stop learning in the face of a pandemic. In the new normal, countries can be expected to invest more heavily in EdTech, continuing working with the nontraditional actors with whom they partnered during the crisis to ensure the continuity of education services. They can include in the curricula and give greater emphasis to nontraditional and 21st century skills. They can make better use of technology by incorporating new ways of learning, including blended models and personalized learning. Making this kind of change a reality requires a vision, strong will, determination, state policies, and steady investments that go beyond a particular government.

Five kinds of changes need to occur. First, following the example of the case studies presented in this book, countries need to invest in connectivity, technological infrastructure, and digital skills, as Uruguay did to level the playing field. They must begin bridging the digital divide by investing in infrastructure and promoting access to devices and connectivity.

Second, ICT must be integrated into teaching and learning practices, building engaging, effective online learning. To do so, teachers will be empowered and trained. Experience is key in this process. If possible, educators learning to teach online should receive at least some of their training through an online course, so that they experience firsthand what it is like to be a distance learner. Data from the PISA show that teachers lack the technical or pedagogical skills to integrate digital devices in instruction, sufficient time to prepare lessons integrating digital devices, and effective professional resources to learn how to use digital devices. They lack incentives to integrate digital devices in their teaching, sufficient qualified technical assistants to provide support, effective online learning support platforms, and school practices that are aligned to make effective use of digital devices. Teachers' capacities to integrate digital devices into instruction varies widely across countries, types of schools and socioeconomic contexts. In LAC, according to PISA 2018, fewer than 60 percent of secondary school teachers have

the technical and pedagogical skills necessary to integrate digital devices in their instruction. Data from the 2018 Teaching and Learning International Survey (TALIS) show that only 61 percent of teachers in Brazil, Chile, Colombia, and Mexico regularly use ICT for projects or classroom related work (Rieble-Aubourg and Viteri 2020).

Third, digital learning needs to become a habit that is integrated into daily routines for everyone. Traditional in-person classroom learning could be complemented with new virtual learning modalities. This crisis has exposed a traditional school model that is far behind the times, missing out on the edge of human innovations that have accelerated progress in many other fields.

Fourth, transitioning between learning in and out of school needs to become feasible and easy, ensuring that the equalizing effect of schools, education and training centers, and universities continues beyond the physical centers. Educational institutions have the potential to help reduce the impact family background has on academic and employment opportunities and the careers of children and young people. The equalizing effects of school fade out when the physical spaces close and learning moves into the family environment, making it entirely dependent on households' resources. The most vulnerable students, who are left without access to educational services, lose what they learned and fail to master new content. In sharp contrast, better-off students keep learning and strengthening what they already know. This pattern needs to change.

Fifth, the entire educational ecosystem needs to be engaged from the beginning, particularly where the ability of the system to move into e-learning is weak. In those cases, public-private partnerships will be critical. The alliances that formed during the pandemic—which brought together governments, the private sector, educational institutions, content and communication platform developers, and telecom and broadcasting networks to craft temporary solutions—could become prevalent and help deliver education services in the future.

With or without Covid-19, to face the massive changes that are transforming work and life for millions of people around the world, societies cannot afford pre–Fourth Industrial Revolution schools. In terms of at basic conditions needed to move into e-learning (connectivity, learning management system, and content platforms), most systems in the region are not ready to make the transition. For this reason, most of them had to adopt low-tech or no-tech solutions during the emergency, using broadcast outlets (TV, radio, SMS) and distributing physical materials (books), for example.

Partly as a result, the crisis will increase the drop-out rate and negatively affect learning outcomes for the most vulnerable students, widening the socioeconomic gap, possibly with lasting effects. When schools reopen, bringing students back into the system and remediating for learning losses among the most vulnerable will be key. Bringing together the efforts of the entire ecosystem to build a new normal in which all students have access to Education 4.0 is critical, because inequality of outcomes today will directly affect equality of opportunity for the next generation.

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IDB Inter-American Development Bank