Working Group Report on Digital Learning

Connecting Learning Spaces:

Possibilities for Hybrid Learning

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BROADBAND COMMISSION FOR SUSTAINABLE DEVELOPMENT

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Foreword

Since the beginning of the COVID-19 crisis, governments worldwide have taken many measures to respond to unprecedented disruption to education. Countries leveraged high- and low-tech distance learning modalities to ensure that learning would not stop even in an emergency context. Such modalities exposed a systemic digital divide, including numerous inequalities and inefficiencies, making clear the need to improve the resilience of education systems and to reimagine education the world over.

While recognizing the growing importance of distance learning, the crisis also underlines the central place of schools as centres not only of learning, but also of protection, engagement, and socio-emotional support. School closures around the world have also reminded us that it is people (teachers, students and their families), not only physical infrastructures, that make up learning settings. Connecting learning spaces and sustaining relationships that create a sense of togetherness and participation are thus essential for building equitable and resilient education systems.

In the search for flexible and sustainable solutions, hybrid learning is quickly becoming a popular option to address the ebbs and flows of an unpredictable global pandemic. Hybrid learning, a model that combines face-to-face instruction with computer-mediated pedagogies, is at the core of the discussion and analysis of pandemic learning that is presented in this report. Hybrid learning is a promising solution for a pedagogy that leverages technology to ensure equitable, quality education and lifelong learning opportunities for all. This constitutes the United Nations' fourth Sustainable Development Goal (SDG 4) and is central to achieving a number of other goals. The investment necessary for hybrid learning can also improve the skills of the whole society.

The key message of this report is that the implementation of hybrid learning strategies requires not only meaningful and affordable connectivity for all learners, but also a policy framework which guarantees that all learners, families, and communities are fully capable of benefiting from the affordances offered by technologies, while also ensuring their safety and privacy.

The report provides informed and contextualized guidance to policy-makers and other education stakeholders who aim to implement new learning strategies, while also acknowledging the benefits and risks of hybrid learning. It stresses the need to have a context-based approach and puts particular emphasis on the multiple enabling strategies required for hybrid learning to be authentically inclusive and equity-minded. Such strategies include (1) a digital skills strategy for life, work, and lifelong learning; (2) a connectivity and infrastructure strategy; and (3) a sustainable funding strategy. In addition, the report offers scenarios for future developments by analysing the impact that emerging frontier technologies such as AI, 5G and blockchain can have on the future of learning.

We take this opportunity to express our sincere gratitude to the members of the Broadband Commission's Working Group on Digital Learning for their valuable contributions throughout the process of producing the report. Its four strands of discussion (hybrid learning, infrastructure, digital skills, and frontier technologies) required a comprehensive analysis that benefited from the plurality of knowledge among the Working Group. By sharing their experiences, expertise, and case studies, they have generated a report that reflects the current challenges and opportunities for hybridity in education. The diverse composition of the Working Group, which includes Commissioners, external experts, and co-chairs from UN and private sector organizations, strengthens and validates this exercise.

We hope that this report supports policy-makers in the development of a whole-government approach that bridges the digital divide, to promote access and skills development for all within an inclusive lifelong learning framework.

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Introducing the Broadband Commission (BBC) and its Working Group on Digital Learning

The Broadband Commission Working Group on Digital Learning is composed of policy-makers and significant partners and actors in the technology industry, as well as intergovernmental organizations (IGOs). It offers a key cluster of experts providing guidance for the international community's dialogue on the recovery, resilience and future development of education and training, with a specific focus on digital learning. During its tenure, the Working Group has generated research and analysis, knowledge and resources, advocacy, and foresight on challenges and opportunities related to hybrid learning.

Having processed experiences from over a year of pandemic-induced remote learning, and through intensive deliberations with the Commissioners and consultations with subject-matter experts, the Working Group on Digital Learning identified hybrid learning as a critical area for further exploration. Building on the legacy of the earlier working groups on Education (2017), Child Online Safety (2019) and School Connectivity (2020), the Working Group set out to identify promising practices and to frame recommendations for countries in taking their digital learning strategies forward.

To this end, the Working Group has focused on four main strands within hybrid learning eco-systems:

1. Infrastructure (led by ITU): Innovation in infrastructure and connectivity operating models to ensure inclusive and sustainable digital learning (in synergy with the Giga initiative, the joint initiative between ITU and UNICEF to connect every school to the internet and every young person to information, opportunity, and choice).

2. Hybrid learning (led by UNESCO): Understanding the human dimensions that facilitate effective hybrid learning, including analysis of appropriate roles for teachers and other facilitators, sustainable models of curriculum-aligned resource production and dissemination, and successful home-based and blended pedagogical learning practices.

3. Digital skills (led by Ericsson): Competencies to use connected technology for learning and empowerment, digital skills for employability, anticipated labour market demands, and abilities to navigate shifting and disrupted labour markets.

4. The impacts of frontier technologies (led by Huawei): Scenarios for the future of digital learning, educational implications and advantages of frontier technologies including AI, Internet of Things, 5G, machine learning, data analytics, etc.

Conscious of the need to support all learners, and taking into account SDG Indicator '4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill', the Working Group has focused on the equity dimensions of hybrid learning and particularly, current inequities with regard to connectivity, skills and educational capacity have been identified. At the same time, there is an awareness that hybrid learning must be compatible with the World Health Organization's recommendations regarding screen time and physical activity for young children, children, youth and adults (WHO, 2018) and be in line with the targets of the Paris Agreement on climate change, including related national actions and campaigns.

Objectives and Structure

The present report integrates the four strands of the Working Group and sets out to examine the local infrastructure, tools, resources, practices, and sustainable financing models needed to ensure equity in future-ready delivery of education. In compiling this report, the Broadband Commission Working Group on Digital Learning has specifically aimed to:

- Analyse the principal models of hybrid learning and components thereof, and the implications for the changing role of the teacher and the human elements of the learning process.
- Identify and compare the main frameworks for digital skills, to inform policy-makers about the structural components of developing a national digital policy in education and training.
- Propose a variety of models to sustainably finance connectivity and infrastructure requirements that must be in place for schools, individuals, and communities to engage different models of digital and hybrid learning, taking into consideration the financial and technical minimum requirements for meaningful connectivity.
- Forecast possible uses of frontier and emergent technologies relevant to education, now and in the future.
- Consolidate a list of overarching recommendations for policy-makers, the private sector, international organizations, and civil society relevant to sustainably supporting digital learning across the continuum of education.

The analysis is organized into three chapters. Chapter 1 defines hybrid learning, highlighting its possibilities and potential to promote access, equity and inclusion through digitalized education alongside the opportunities and risks that this carries. Chapter 2 suggests four components of an enabling environment for hybrid learning: the transition to digital societies, overcoming the digital divide, investments in the digital transformation of education systems, and efforts to ensure sustainable funding, including alternative funding models. Chapter 3 reflects on the impact of frontier technologies on hybrid learning, including fifth generation cellular networks (5G), artificial intelligence (AI), blockchain and cloud-to-edge developments. The report concludes with a set of policy recommendations, as well as a compendium of case studies which aims to provide examples of best practices.

Executive Summary

The COVID-19 pandemic has impacted on education systems the world over. Millions of students have been affected by school closures at some point over the past 18 months, and this situation is likely to persist in many countries through late 2021 and 2022. Learning loss is a reality for many, and the longer children stay out of school, the less likely they are to catch up with age-appropriate learning targets or even return to the classroom. The longer term consequences for young people, communities and societies include socio-emotional trauma, vulnerability to poverty, poor nutrition and health, as well as weaker employment and income earning prospects. This period also threatened the respect for the right to education.

The pandemic demonstrated how digital technologies are making the world more interconnected and interdependent than ever before, but also revealed a deep divide between those with access to online services and learning spaces and those who are digitally excluded. In education systems that were not digitally mature, the overnight shift to remote teaching and learning has heightened educational inequalities and has had other harmful impacts including increased student isolation, less professional autonomy for teachers, and a shift from publicly provided to commercial and privately controlled educational spaces and content.

Solid investments, planning, participatory approaches and involvement of all concerned stakeholders are essential to ensuring all children, young people and adults, not just the most advantaged, can benefit from flexible models of learning now and for years to come.

However, most critically, the work involves consideration of hybrid learning ecosystems from every entry point. This includes not only the contributions of ministries of education and their ed-tech and telecom partners, but also those of school leaders and teachers on the front line of digital transformation, as well as universities, innovation hubs, communities, civil society, publishers, and content editors.

Sustainable hybrid learning systems should be inclusive, generating value through contextualized and open educational resources. They should celebrate local identities and languages, while benefiting from global ecosystems, initiatives, value chains, resources and knowledge.

Hybrid learning: Rethinking possibilities

Hybrid learning models can be designed in various ways, around a range of learning objectives and incorporating different pedagogical approaches and technologies. In non-emergency contexts, hybrid learning generally enables students to study in flexible ways, online or face to face, according to their circumstances and preferences. The online and ICT components are often used to supplement or even supplant 'seat time' activities. A hybrid teaching session may have some students in class and some participating remotely (i.e. heterogeneous learner groups). Crucially, students have some control over the time, place, path and/or pace of study.

The precise nature of hybrid learning will vary significantly depending on context, circumstances and requirements. Models can be synchronous, asynchronous, bi-directional, multi-directional, and highly or loosely structured, and engage differing numbers of learners. Different pedagogical approaches are possible including rotations, flipped classrooms, flex and à la carte models, and enriched virtual approaches.

Hybrid learning approaches have the potential to transform the delivery of education: affecting the nature of learning spaces and who gets to participate; generating flexibility with the potential to extend access to basic education, non-formal/informal learning and social learning within communities; supporting more innovative pedagogical approaches and teachers acting as educators; offering customized and differentiated contents; providing new opportunities for teachers' professional development and training; and impacting on the costs of learning overall. Access, equity and inclusion are therefore central concerns for policy-makers and other education stakeholders, as digital divides challenge students in different circumstances, including those living in crisis contexts, such as low-income students, girls and women, refugees, and learners with disabilities.

Hybrid learning also carries risks and challenges, however. These include inequalities in access, often caused by gaps in affordability, digital devices and bandwidth; professional development programmes failing to impart the necessary digital skills to support hybrid teaching practice; weak attention to pedagogy and poor lesson design; difficulties in maintaining engagement between teachers and students; potential biases inherent in automated tools that may not be designed with learners in mind; a lack of appropriate learning content; the alienation of educators from the learning process; the replacement of educational institutions with technological fixes; and limited use of hybrid learning owing to societal contexts or learner preferences.

Enabling strategies for hybrid learning

Towards digital societies

To make hybrid learning a viable option, countries will need to design and implement enabling strategies facilitating the interpenetration of digital technology in education and training systems.

A first component of an enabling environment for hybrid learning involves countries' efforts to transition toward digital economies and societies. Along this path, three main steps for decision-makers can be identified:

- **Assessing digital maturity:** Digital maturity models help governments and organizations assess their digital maturity level, namely, the state and the capabilities of a system in effectively managing and guiding digital transformation efforts. Several models have been developed by think tanks and the foresight and intelligence units of international corporations, intergovernmental and international organizations, and private sector actors. They suggest that digital maturity is highly correlated with per-capita income: the more mature and diversified an economy is, the likelier it is to have suitable infrastructure, institutions, regulations and human capital. However, access can still be uneven.

- **Identifying and assessing skills through digital skills frameworks:** Digital skills frameworks categorize and organize the complexity and range of digital skills perceived as essential in today's world.

They allow governments, firms and digital skills providers to identify and assess skill levels among students, trainees or employees and offer relevant digital skills development programmes.

- **Investing in human capital through digital skills policies and programmes:** A rising number of governments have recognized the significance of investing in digital skills and digital inclusion. The COVID-19 pandemic further demonstrated the importance of ICT, with governments having to deal with increased demand for ICT services and accelerating the digitalization of education and other public services. Private firms also invested in reskilling and upskilling their employees, prioritizing skills that allowed remote teams to collaborate effectively during lockdowns.

Overcoming the digital divide

A second component looks at countries' efforts to overcome the digital divide, which is manifested in:

- **Infrastructure and access to the internet and digital devices:** Estimates suggest that $428 billion would be needed to achieve universal access to broadband connectivity globally by 2030, or $40 billion a year on average.[1] Technologies involved include 4G, 5G, Wi-Fi 6, satellite, WISP, and/or fibre, each with distinct advantages and disadvantages, in terms of capacity, latency, scalability and costs.

- **Coverage:** The heterogeneous geography of broadband infrastructure and investment results in variable service provision. Large disparities exist in both access and performance within different geographic locations.

- **Access and usage:** Coverage does not necessarily translate into internet use. An estimated 3.7 billion people worldwide remain offline, the majority of whom are living in developing countries where an average of just two out of every ten people are online.

- **Meaningful connectivity:** A large proportion of people who are connected to the internet do not have the quality of access required to use some of its more valuable features.

- **Affordable connectivity and devices and lack of digital skills:** These remain key barriers to the uptake and effective use of the internet, especially in the world's least developed countries and in rural and marginalized communities.

Supporting the digital transformation of education systems

Aiming for a digital transformation of education systems in alignment with the national digital strategy is a crucial component. The report recognizes and appreciates the integrated nature of investments and support strategies at different levels of education management, teacher preparation, pedagogical approach and school readiness. These are required in order for the hybrid learning value chain to be functional. Networked and interdependent relationships among many public and private sector actors and local stakeholders are also critical.

The report therefore outlines the following steps: consideration of existing levels of digital integration within education systems; investing in infrastructure development;

1 Assumes 90 per cent uptake by people aged 10 years and older with 4G or equivalent connection (10 Mbps). See https://www.itu.int/myitu/-/media/Publications/2020-Publications/Connecting-Humanity.pdf

ensuring school-level readiness in relation to infrastructure and connectivity; assessing teachers' readiness for their new roles, providing support and training for teachers and strengthening school leadership; updating curricula and contents; improving learner and household readiness; and setting up system-level interventions.

Self-sustaining funding for hybrid learning

Ensuring sustainable funding is the fourth component of the enabling environment.

- Any hybrid learning financing framework should be based on the following principles: equity and inclusion, a learner- and educator-centred ethos, a focus on meaningful connectivity, and the integration of hybrid learning objectives with national and international education goals.

- The costs of hybrid learning are driven by telecommunications infrastructure and the regulatory environment; investment in digital skills, learning devices and classroom equipment for students and teachers; curriculum alignment, digital contents and OER platforms; and investment in the professional development of the education workforce as well as in school infrastructure and recurrent costs such as electricity and building maintenance.

- Funding sources vary. Investment in infrastructure can be secured through public funding, commercial models, community cost-sharing models or community networks. The financing of ICT devices can be covered through government support, subsidies, leasing and cooperative purchasing. Digital skills development usually depends on government funds, development aid, multilateral banks and innovative financing mechanisms and sources. Several countries are also using Universal Service Funds. New funding arrangements are emerging that support access to digital content for hybrid learning, including the collaboration and engagement of communities, state and non-state stakeholders, institutions, and international donors.

- Cost simulations can be carried out as a national policy and investment tool. The report describes a cost simulation model developed by UNESCO and applies the model to Honduras and Sierra Leone.

- The report zooms into infrastructure investments and finance models, discussing how choices affect costs and elaborating on three primary funding sources or archetypes (commercial provided, government-contributed, and community-based). A decision tree is proposed for the consideration of sustainable funding sources, with acknowledgement that the involvement of different funding actors is likely to change over time.

To realize school connectivity, the report presents a variety of management and operation options. Using the cases of Rwanda and Brazil, it shows different funding models to consider based on each country's context, current connectivity and infrastructure requirements. In addition, it suggests an iterative roadmap to identify sustainable business models for rolling out school connectivity.

Framing future developments

Frontier technologies provide a basis to reconsider how future economies, societies and education systems might be shaped, developed and organized. Current technological developments include AI, machine learning, big data and data analytics, 5G, Wi-Fi 6, blockchain and distributed ledgers, and cloud-to-edge technologies.

5G (Fifth generation cellular networks)

5G has many potential benefits for hybrid learning. For instance, 5G can enable access to learning through any connected device. Greater bandwidth provides more stability and speed, enabling larger numbers of students to learn online, using multiple devices and a wider range of applications. Faster mobile internet speeds can also help us reconsider how and where learning can occur by supporting greater and more effective experiential, located, remote, and problem- and project-based learning in the field and on the job. However, in terms of 5G being used for hybrid learning, there are still barriers ranging from cost to general internet risks, and network and system compatibility challenges.

Artificial intelligence (AI)

AI combines computer science and robust data sets to enable problem-solving (and problem-setting), often performing tasks that typically require significant human effort and large investments in time and resources. AI has the potential to provide a more diverse range of learning experiences. Machine-based learning has the potential to intelligently respond to students' learning objectives and needs. Concerns about the design, use and implementation of AI in education have emerged, related to data security, safety, tracing, and different kinds of biases and other associated ethical concerns, especially when data sets are shared across networks and systems. Furthermore, many contexts do not have the necessary processing, connectivity or infrastructure requirements to incorporate the most dynamic and interactive elements into learning experiences effectively.

Blockchain

The value of blockchain for hybrid models will likely be perceived in terms of its potential to address the growing need to assure consistency and verification processes and to avoid fraudulent manipulation, especially given the varied contexts, locations, and multitudes of partners and awarding bodies involved in hybrid learning globally. One obvious challenge for end users is that they require access to the internet, which is not available to all. A second major challenge is that blockchain is based on public-key cryptography. Users need public and private encryption keys to use the system. When the private key is lost, access to the content of records is lost.

Cloud-to-edge developments

The move from centralized cloud computing towards localized edge computing opens a range of new learning and interaction possibilities. Whilst the cloud is the central hub for data processing and analysis, edge computing is where processing and data analysis are enabled locally. This could potentially foster a new culture of context-sensitive digital pedagogies and customized applications suited to specific needs, a key requirement for more effective hybrid learning. However, more broadly, it opens up new possibilities for learners to be supported by AI that monitors, manages, facilitates and enhances learning, challenging traditional notions of what learning entails and the spaces in which it occurs, and creating possibilities for new pedagogical approaches, configurations of teacher-student relationships, and teaching organization and practice. Numerous challenges are associated with moving from cloud to edge, including the need for new distributed software architectures, and ways to disseminate and orchestrate services. There are obvious cost and return-on-investment considerations, and concerns about both deployment and integration, especially where these are associated with incorporation into rigid and structured education systems. This will require coordinated global, national and local strategies for implementation, interconnected with other policies and strategies, to ensure equal benefits for all.

Frontier technologies' impact on hybrid learning: Scenarios

The report details three general scenarios related to the future of hybrid learning facilitated by 5G, AI, blockchain, and cloud-to-edge development: 'systems extended' (the existing system adapts to new developments and opportunities to create enhanced and enriched learning experiences, tailored to need);

'systems restructured' (there has been a significant move away from traditional configurations of education around highly structured/rigid systems, institutional requirements, qualifications and measures); and 'systems reinvented' (climate change results in an epoch-defining shift and education is reconceived as a global, collective endeavour, in which new inter- and intra-national learning collaborations are established).

Any plans to further roll out digital technologies might need to be accompanied by a concomitant plan to redress energy consumption and unethical practices in extraction, manufacturing, and production.

Recommendations

The Working Group recognizes the importance of technological innovations and the potential transformative impact of telecom and digital technologies on educational access and delivery, while noting that schools remain a central interface of learning alongside other services providing nutrition, health, and child safeguarding. Technologies can change and improve learning, which in turn can help societies realize their diverse educational goals. It is therefore critical to tackle the digital divide, by both facilitating access to connectivity and supporting the development of hybrid learning.

In the light of their findings, the members of the Broadband Commission Working Group on Digital Learning recommend that governments and other stakeholders take the following five actions:

1) Promote hybrid learning to recover from the pandemic, reimagine education, and narrow the digital divide

Governments and national stakeholders should decide which models of hybrid learning are the most appropriate and identify the contexts and situations where they may work best. The pedagogical focus should be on student-centred, active and collaborative learning. However, further research is needed to identify how hybrid learning can best integrate these pedagogical approaches.

Moreover, stakeholders should recognize the central role played by teachers and support staff as agents of change, and provide adequate training and in-service professional development, together with initiatives to nurture their well-being and mental health. The development of communities of practice and peer learning activities shall also be supported.

Open educational resources (OERs) and other free-of-charge and quality-assured digital content should be promoted and aligned to national curricula, cultures, languages and identities. Ultimately, hybrid learning models, like their traditional counterparts, must be designed with a focus on inclusion and equity, prioritizing those who are most at risk of being left behind, including low-income students, women and girls, persons with disabilities, people on the move, migrants, refugees, and other marginalized groups.

2) Adopt a national strategy for digital skills development for life, work and lifelong learning

The Working Group members recognize that capacity gaps remain a persistent barrier to narrowing the digital divide. Governments must increase their efforts toward skilling, reskilling, upskilling and capacity building to leverage digital technology for life, work and lifelong learning and other socially beneficial purposes. This is especially urgent for disadvantaged groups including girls and women, and young people who are not in education, employment or training (often referred to as NEETs).

In order to foster a digitally ready society, national stakeholders should define system-wide strategies for skills development designed to address specific social and economic needs in today's society. These strategies should be based on robust national digital skills assessments and align with hybrid learning requirements and the government's goals and plans to embrace digital transformation. They should also refer to available international digital skills frameworks and taxonomies and adapt them to the country's needs. This will provide a reference structure and tools for assessment, certification, monitoring and evaluation, and allow for comparative analyses across regions. Furthermore, a government should engage all relevant stakeholders when designing and implementing its digital skills strategy, and strive to leverage existing private and public initiatives, competences and investments.

3) Promote whole-of-government and public-private partnership approaches for connectivity and infrastructure

Government and state actors play a leading role in setting the conditions for sustainable and equitable provision of education and training. They should continuously promote cross-ministry coordination, joint initiatives and policy alignment for connectivity and infrastructure in relation to hybrid and remote learning. This can be accomplished by developing appropriate governance and regulatory frameworks; planning and coordinating national policies and implementation strategies; creating and managing public-private partnerships; and mobilizing and efficiently exploiting resources.

Success hinges on public and private entities sharing a common vision and understanding each other's contribution. This should be demonstrated both in official documentation and in practice on the ground. To measure progress in terms of access and outcomes, national stakeholders should collect and disseminate data and information regarding the digital divide, hybrid learning, access to connectivity and infrastructure, and the digital transformation of education and training systems.

Private sector organizations operating in the hybrid learning ecosystem need to be regulated, especially regarding the use of proprietary tools and services in education. Stakeholders should also encourage the educational technology industry to act as an essential partner in building thriving local ecosystems and promoting the local development of frontier technologies for education. For this purpose, instead of public education and training bodies viewing this industry just as a provider of goods and services, they could consider other types of relationships with them, including partnerships for funding, research, internships, apprenticeships, and collaboration to develop standards.

4) Establish stable, self-sustained financing solutions for connectivity to support hybrid learning

Financing quality education, including digital transformation, remains a major challenge, particularly in low- and middle-income countries. During the past decade, government spending on education increased steadily; however, the pandemic constrained public finances and hindered prospects for sustaining these positive increases. As a result of the public health crisis, most governments in low- and middle-income countries were only able to invest in education with the support of the international community and private industry.

Reliance on ad-hoc initiatives and donor funding does not represent a long-term, stable financing solution (which is necessary for achieving the SDGs). Given that connectivity and hybrid learning are not 'one-time' expenditures, they should be featured in institutions' budgets (as a recurring cost) and, ideally, part of the government's broader educational policies and sector plans. More robust, predictable, and sustained investments are necessary.

A hybrid learning policy and costing approach requires all significant elements, enablers and building blocks of the hybrid learning ecosystem to be considered. It requires coherent, systemic and ongoing efforts by the public sector, even if it relies on commercial or community models, to provide financial and/or regulatory incentives for telecommunications infrastructure. Countries with a demonstrated ability to execute such investment coherence are more likely to reap the benefits of hybrid learning.

To enhance the efficacy of hybrid learning, governments can consider as a guideline this report's suggested model for integrating digital transformation into education policies and sector plans. Additionally, they may adopt the report's proposal for a roadmap for rolling out connectivity in their schools through an iterative five-step process from framing the initiative to selecting technological provision and funding methods and finally determining which operating model to implement. Stakeholders should engage in a policy and social dialogue on the cost-effectiveness of different implementation models.

Because a self-sustaining and comprehensive hybrid learning investment framework concerns the whole of government and many sectors and types of partners, it requires a cross-sector policy framework, participatory planning, and social dialogue.[2] Future investment decisions should be addressed in policy dialogue; however, financing the hybrid learning transition and transformation may also build on existing levels of cooperation

2 The government will have to continue to be responsible for educational improvement and expansion, and education will likely continue to be financed publicly. The public sector will need to continue setting hybrid learning standards and decide how to allocate resources.

among various stakeholders. Each country has its own history of trust and collaboration between government and private sector financing, such as delivery schemes, resource allocation models (supply- or demand-oriented), and even the administrative structures and processes for digitally oriented educational reforms. Financial resources and competing needs will influence the decision-making from country to country, as will the structural features of education, ICT and telecommunications governance and existing financing frameworks. In summary, no single approach is appropriate for all societies and educational systems.

5) Proactively anticipate the impact of emerging technologies

Hybrid learning together with the requirements related to digital skills and competencies constitute an area of education that is changing continually in tandem with the development of new technologies. The Working Group discussed the rapid growth of 5G mobile internet access, Wi-Fi 6 wireless access, cloud-based computing, AI and blockchain.

National stakeholders should anticipate the impact of frontier technologies on education through foresight exercises, scenario building, data monitoring, and qualitative as well as quantitative research. The resulting information will help guide the development of hybrid learning systems and resources. This in turn will contribute toward empowering teachers, enhancing lifelong learning, improving methods of assessment and certification, and putting innovation to work to solve educational problems and inform investment decisions.

Governments should mobilize interdisciplinary and multi-stakeholder expertise to inform and build the capacities of policy-makers. In doing so, they can more easily develop and implement appropriate policies and regulatory frameworks for the ethical and human-rights-based use of frontier technologies, regarding learners' data protection and security.

Finally, combining digital developments with more sustainable practices must be at the forefront of responsible strategic business and political planning.

Introduction

Since the start of 2020, education has changed dramatically the world over. At the time of writing, the statistics are well-known; half of all students globally are still affected by school closures as a result of COVID-19 with over 100 million more struggling to achieve reading proficiency (UNESCO, 2021g). In 2020, schools around the world were fully closed across all four education levels for 79 instructional days on average, ranging from 53 days in high-income countries to 115 days in lower-middle-income countries (UNESCO, UNICEF, World Bank and OECD, 2021). Learning loss is a reality, and the longer children stay out of school, the less likely they are to ever return. Moreover, interrupting education has long-term consequences for societies, such as increased inequality, reduced social cohesion, and poorer nutrition and health.

A world of interdependence. The COVID-19 challenges provided a test of the resilience and adaptability of communities, states, and the international community, often exceeding the capacity of existing systems and models. It demonstrated the interdependence of our health, economic and education systems, and the impact of inequalities in all these areas. It also showcased a world more deeply interconnected and interdependent than ever before as a result of innovations such as low-cost computing, the internet, and mobile connectivity. The pandemic exemplified the concept of an 'age of inter-dependence' (UN, 2019) and the need to reinforce international cooperation and multilateralism.

Deepening inequality and reversal of achievements. The pandemic has exposed the digital divide within and between countries. The disproportionate impact of COVID-19 on low-income learners has caused them to fall further behind, and the learning loss is global and significant (UNESCO, UNICEF, World Bank and OECD, 2021). The result is a major increase in educational poverty, which threatens to reverse years, if not decades, of progress towards SDG 4. The transition to remote learning in the context of COVID-19 could lead to dramatic setbacks for school enrolment and learning outcomes, especially in developing countries, with dropout risk and learning losses being greater among the most marginalized (Lichand et al., 2021).

Ed-tech moving from the periphery to the centre of education systems. The shift to distance teaching and learning has been the key immediate policy response to ensure the continuity of education despite school closures (G20 Italy, 2020). Countries employed a mix of high- and low-tech distance education modalities ranging from online learning, radio and TV to take-home resources. According to a joint survey by UNESCO, UNICEF, the OECD and the World Bank (2021), most countries (89 per cent) have introduced at least one measure to increase access to the devices and connectivity needed for online learning. This most frequently took the form of making access available through mobile devices or offering subsidized or free internet access. Most countries (91 per cent) have also taken measures to support populations at risk of being excluded from distance learning platforms, most commonly learners with disabilities. Around the world we have seen promising examples of connectivity and digital resources being harnessed for education. However, over 30 per cent of low-income countries have not introduced any measure to support access or inclusion. We have witnessed the many ways in which connected educational technologies can worsen learning inequality; increase student isolation; narrow and privatize educational experiences; homogenize teaching and learning; undermine the professional autonomy of teachers; produce harmful environmental impacts; violate privacy and trust; and consolidate power and control outside public oversight (UNESCO, 2021f).

Importance of inter-sectoral and multi-stakeholder international cooperation. In particular, the Broadband Commission's efforts to advance multilateralism, international solidarity and knowledge sharing is the key to charting a new course for connectivity[3] in education, one that makes technology serve learners, teachers, and educational institutions. The UN Secretary-General António Guterres called on governments and donors to prioritize education for all children and youth during the pandemic, renewing efforts to implement his Roadmap for Digital Cooperation. UNESCO responded to this call by creating the Global Education Coalition, bringing together 175 institutional partners from the UN family, civil society, academia, and the private sector. The Coalition supports governments in strengthening distance and hybrid learning, training teachers, narrowing digital divides and equipping children, youth and adults with the skills for life and work.

3 The Broadband Commission calls on the global community to mobilize efforts to achieve the 'Global Goal of Universal Connectivity' in support of the UN Secretary-General's Roadmap for Digital Cooperation and other connectivity initiatives: https://broadbandcommission.org/manifesto/

1

Hybrid Learning: Rethinking Possibilities

Chapter 1: Hybrid Learning: Rethinking Possibilities

The rapid shift toward distance and online teaching and learning was an immediate policy response to ensure the continuity of education in light of educational institutions closing during the COVID-19 crisis. Hybrid learning emerged as a critical model of delivery and has been central to the emergency measures and in some cases to the recovery response efforts. However, its utilization is still relatively new in many countries.

The first section of this chapter considers what hybrid learning is and why it is important (1.1). The next part explains the need to place access, equity, inclusion, and local relevance at the centre of the design and development of hybrid learning (1.2). The final part (1.3) outlines some of the key opportunities and risks of hybrid learning in relation to learning pedagogies and environments; considerations of individual learners and contexts; and educators' changing roles and the support, training and professional development available to them. The discussion and more tangible insights regarding the practical integration of hybrid learning across educational systems and institutions are addressed more closely in Chapter 2.

1.1 What is hybrid learning and why is it important?

The past 15 years have seen a massive increase in the use of digital technologies in education and training around the world, and the pandemic has quickened the pace of this integration. Indeed, recent interest in hybrid learning has grown largely due to necessity arising from the COVID-19 crisis, as well as the greater flexibility of delivery that it offers. However, hybrid learning is not a new mode of education. It has been applied for a wide range of learning purposes and utilized effectively in a range of different contexts and settings for many years.

■ *What do we mean by hybrid learning?*

There are numerous interrelated terms such as *digital*, *distance*, *remote*, *online*, *blended* and *hybrid*, which imply models of learning that usually include both an online and offline component. A common element across all these terms is that they have a close and direct relationship with the use of technologies and digitalization in education.

For the purposes of this report, we use the below definitions to create distinctions relevant to the discussion.

- **Digital learning** is any type of learning that is accompanied by technology or by instructional practice that makes effective use of technology. It encompasses online, blended and hybrid learning.

- **Online learning** is distance learning that can be done at any time or place, provided learners have access to the internet. It can be divided into three main categories: platform-based learning, teacher-directed live streaming, and video-based flipped learning. Online learning can be delivered through the synchronous modality in real time, with students and instructors attending together from different locations. It can also be provided in the asynchronous modality, which is run on a more relaxed schedule, with students accessing class materials during different hours.

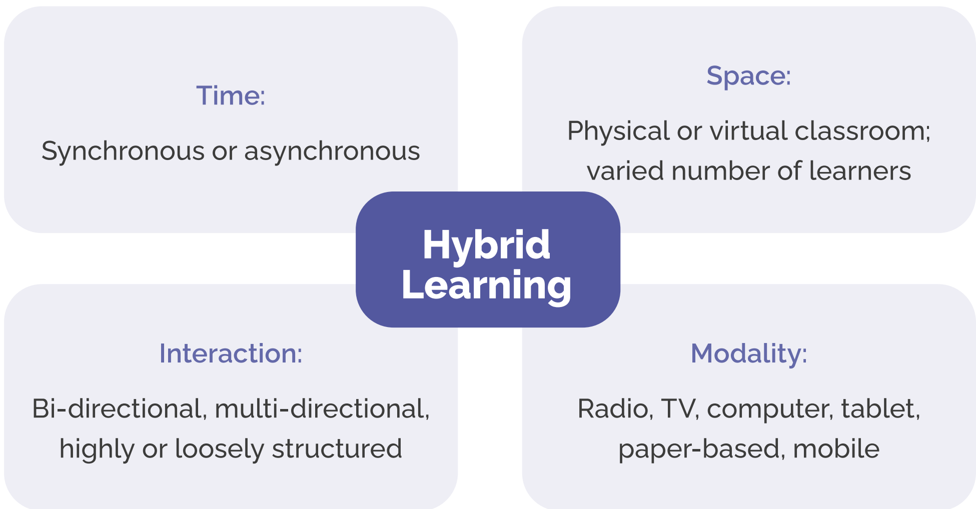
- **Blended learning** combines face-to-face teaching with online learning activities. All students generally engage in the same activities and keep a similar pace. Teaching activities are designed to make good use of media and setting.

- **Hybrid learning** enables students to study in flexible ways, online or face to face, according to their circumstances and preferences. A hybrid teaching session may have some students in class and some participating remotely (heterogeneous learner groups). Crucially, students have some control over the time, place, path and/or pace of study. The online and ICT components are often used to supplement or even supplant 'seat time' activities.

Hybrid models may be designed in various ways, around a range of learning objectives and incorporating different pedagogical approaches and technologies. The precise nature of hybrid learning and teaching experiences can also vary significantly depending on the context, circumstances, target groups and requirements. With this in mind, hybrid learning models can be synchronous, asynchronous, bi-directional, multi-directional, highly or loosely structured, and designed to engage differing numbers of learners.

For a visualization of the plurality of hybrid modes, see Figure 1.

Figure 1. Defining the dimensions of hybrid learning[4]



4 Figure adapted from World Bank (2021b).

Why is hybrid learning important?

Hybrid learning approaches can transform the delivery of education. Even pre-pandemic, education commentators suggested that innovations in education and training that involve new teaching and learning pedagogies correspond to the early stages of a learning *transformation*: a significant change in the use of technology in classrooms (e.g. virtual learning environments, adaptive learning, immersive environments, mobile learning and flipped classrooms), and a shift in pedagogy including student-centred learning, problem-based learning and students as co-creators (Hazelkorn and Edwards, 2019).

The broad adoption of hybrid learning over the past 18 months is an indicator of this learning transformation. Forms of innovation are disrupting existing – and often long-established – ways of teaching and learning. The types of hybrid learning manifested over the past year indicate its potential to transform:

- **Who learns**, opening up the infrastructure for learning to groups who may not have been reached before (through investments in infrastructure, bandwidth, connectivity, new technologies, etc.);

- **Where learning happens**, opening up forms of learning in online spaces and enabling learning anytime, anywhere through fixed and mobile devices;

- **How teachers educate,** imparting learning via more diverse modalities than the blackboard and textbooks, including multimodal channels and interactive technologies;

- **Relationships between teachers and learners, and amongst learners,** especially where AI supports greater reactivity to learning challenges and more personalized learning paths, and learners are able to cooperate autonomously through interaction on digital platforms enabling shared online writing;

- **Approaches to learning**, enabling customization and providing instant, real-time and sometimes more detailed and accurate feedback to learners; and

- **Learning content and resources**, opening up knowledge that was once inaccessible, in particular through OERs and promoting 21st century skills using media that are commonplace outside the traditional learning settings.

Brief overview of different approaches and how they might be used

Educators can use different pedagogic approaches to support learning and skills mastery and leverage technologies with different functionalities to enhance engagement, diversify educational experiences and offer greater learner choice and control. Many emerging hybrid approaches also support learners to engage with non-formal training and enable them to capture evidence of skills application ‘in-situ’ or ‘on-the-job’, in a wide range of contexts and locations.

Some of the most common approaches are known as Rotations, Flipped Classrooms, Flex, À La Carte, and Enriched Virtual.

Table 1. Quick overview of different hybrid and blended learning approaches

Rotations
Some of the most common models employ rotations, which cycle learners through different learning activities, either alone or in groups, according to a pre-determined schedule. Whilst rotations can be utilized through in-person and blended learning experiences, they can also be effectively incorporated in hybrid models, with those not in class focusing on particular tasks, then feeding back to, and interacting with, in-class groups.
Flipped Classroom
In a flipped classroom, learners encounter new content before class, often online or through their course platform. This may be in the form of videos, readings, or other conceptual activities. Class time is then reserved for interaction through discussion, peer collaboration, or project-based learning. Learners attend class, either in person or virtually, well prepared to engage with the topic at hand. While flipped classrooms need not employ any technology in theory, in practice online tools are an efficient way to deliver content at scale.
Flex
The Flex model, by contrast, relies heavily on online learning, in part because it is one of the methods that promote the greatest *flexibility* for learner independence and agency. Here, students work through the learning materials at their own pace, and the schedule of activities adjusts to their needs. Teachers provide support as needed, acting as a mentor and guide. Students have a keen awareness of both the curriculum and their progress, and they may even be tasked with setting their own learning goals, in partnership with their teacher, as well as tracking their advancement toward those goals.
À La Carte
Similar to ordering from a menu, the *À La Carte* model allows learners to choose external, for-credit online courses that interest them and complement their regular course of study, whether primarily virtual or face to face. This gives learners a great deal of authority over their schedules, and embraces interest-driven learning as a driving principle. Learners can take courses online with peers worldwide, moving from local to global interaction and broadening social and academic circles. This model creates an ideal pathway for advanced learners to benefit from learning opportunities beyond what their institution may offer, to enable progression at their own pace. Educators may also offer À La Carte options to learners within a given in-class activity or project, if these options also support their specific learning objectives.
Enriched Virtual
Another model structured around home-based online learning is the Enriched Virtual model. Learners take most courses online in lieu of 'seat time' in a traditional classroom. Still, they also attend a physical school for select in-person classes with their teacher a couple of times per week to supplement their online work and keep them on track. One significant advantage of this model is the ability for students who have jobs, internships, family commitments, or other responsibilities, to schedule their face-to-face class time around their lives. Owing to the high degree of autonomy, this model is perhaps more suited to older learners than younger ones.
HyFlex and Modified Tutorial
Two additional hybrid learning models, particularly suited to higher education and technical and vocational education and training (TVET) learning, have become increasingly popular in recent years: the Hybrid-Flexible (HyFlex) model, and the Modified Tutorial model. The **HyFlex** model maximizes versatility and learner choice; in this model, each class is offered via three delivery modes: in person, as well as both synchronously and asynchronously online. Not only can students decide how they want to enrol, but faculty also choose the manner in which they wish to teach the course, either virtually or in person. **The Modified Tutorial model makes** use of small group learning circles, or tutorials, and often employs a flipped classroom approach for the group sessions. Content and lectures are delivered asynchronously online, followed by facilitated small-group discussions (World Wide Technology, 2020).

Ultimately educators must decide which is best for their learners and the context in which they work. And as in all education and training systems, schools and teachers will need to be empowered to find an optimum balance between virtual and in-person learning.

When all things are considered, simpler approaches such as station and lab rotations may be more suitable for those educators (and learners) attempting hybrid models for the first time before progressing to more challenging methods of delivery. These approaches may also be more suited to low-resource contexts, although more complex methods may be possible by utilizing low-tech modalities. In contexts where space and devices are limited, station rotations and flipped classroom approaches can use existing classrooms and devices for a subset of the total number of learners.

For post-secondary and post-compulsory education, HyFlex and Modified Tutorial approaches may work better and offer greater flexibility for learners as they can participate at times to fit around existing work, family, or other commitments. Meanwhile, educators designing work-based and skills development training may consider approaches such as Enriched Virtual and Rotations to be more applicable. They lend themselves to hands-on and performance-based tasks and can be utilized to make the most of 'in-situ' learning.

1.2 Access, equity and inclusion at the centre

Before any meaningful discussion of how to deliver hybrid learning can take place, teachers, school leaders, and policy-makers must first assess who has access to these models of education, and who is being left behind. Enshrined in the Universal Declaration of Human Rights in 1948, the right to education is inviolate. This right was reinforced in numerous subsequent international instruments, including the International Covenant on Economic, Social and Cultural Rights (1966), the Convention on the Rights of the Child (1989), and the UNESCO Convention against Discrimination in Education (1960).

The world is becoming more reliant upon technology, and a natural consequence of this is technology's deepening integration within education systems and curricula. It stands to reason, therefore, that the right to a connected, hybrid education naturally follows from the right to education, if this is to be a major mode of delivery in an increasingly digital world. Countries such as Estonia have been forward-thinking in this regard, declaring internet access a human right as far back as 2001 (Weale, 2020) and prioritizing the digital skills and infrastructure investments to follow through on this claim. But many others have yet to follow suit.

The right to education does not stop at the onset of crises, be they natural disasters, man-made catastrophes, or public health emergencies. Ensuring that all students can access their education through multiple channels, including hybrid learning, is a human rights issue.

- ***The digital divide***

Societies must ensure that the most marginalized people also have access to the tools and support needed to engage with hybrid learning. In the least developed countries, just 25 per cent of people can access the internet; even more alarming, only 10 per cent of those living in rural areas can (*The Economist* Intelligence Unit, 2021). Around 2.2 billion children and young people under age 25 lack the means to connect to the internet (UNICEF, 2020). While over 80 per cent of G20 countries offer free or subsidized access to connectivity and devices, only 40 per cent of countries globally can do so for devices and less than 60 per cent for connectivity (G20 Italy, 2021).

- *The disadvantaged target groups*

Girls and women experience particular barriers related to accessing education. Gender stereotypes often limit their activities, opportunities, potential, and self-perceptions. Girls are at higher risk for child marriage and early pregnancy, which impacts their ability to progress through school more generally, and their ability to allocate time to studying outside of school. Unfortunately, in many places the threat of gender-based violence keeps girls from attending school at all, as travel to and from schools may be too dangerous. These threats also exist in online spaces, where girls may be victims of sexual solicitation or abuse. Many schools in less-developed countries lack safe washing facilities, which discourages girls from attending. Poverty is another challenge, as poor households cannot pay costs associated with school, and may prioritize boys' education while leaving girls to care for siblings and work at home (World Bank, 2021a). In countries with traditional social norms where gender inequalities are high, the design and implementation of ed-tech initiatives can reflect and reproduce these inequalities, leading to greater benefit for boys than girls (Crompton et al., 2021). Ensuring physically and emotionally safe spaces for girls, both in physical and online locations, is essential to help overcome these barriers and inequalities. Teachers and families should be supported to identify and reduce their biases toward girls' use of technology and access to education. Governments should strengthen the resilience and gender-responsiveness of their education systems, and curricula and hybrid programme design must be inclusive and responsive to the needs of girls in their particular context.

Refugees and forcibly displaced people experience numerous challenges when attempting to access quality education, including hybrid learning. Access to connectivity and devices is but one obstacle among many, such as a lack of education and identity documentation, limited recognition of prior learning, language and cultural barriers, prolonged interruptions to their learning, and difficulties meeting the enrolment requirements of schools in the host country. The lack of connectivity makes it harder for refugees to communicate with family, and empower and mobilize themselves to claim their rights; it inhibits self-reliance and innovation (UNHCR, 2021). Connectivity can link refugees to protection, education, and economic opportunities, but is often unaffordable for people forced to flee. Refugees are 50 per cent less likely to have a smartphone, and 20 per cent of rural refugees are completely disconnected (UNHCR, 2017). However, through initiatives to increase refugees' connectivity, blended and hybrid learning models have proven invaluable, for example enabling students in the Connected Learning in Crisis Consortium to flexibly obtain recognized tertiary and vocational credentials. UNESCO's Qualification Passport for Refugees and Vulnerable Migrants (UQP) is another important international tool developed to support recognition of refugees' skills and qualifications and facilitate their entry into higher education. Online tools can also help refugees learn new languages and integrate into their new education systems and host communities. In contexts where population density is high and there is limited space or multiple shifts in physical schools, access to learning centres with connectivity and computers can allow learners to continue their education.

Learners with disabilities have their own set of unique challenges. Where hybrid learning is concerned, they may face difficulties accessing public spaces, which may not be equipped to cater to their specific needs both in transit to school and while at the school itself. Social stigmas may also stop these children and youth from being included in the formal education system. Blind children may have difficulty navigating online learning portals and resources, while deaf children may not take advantage of certain multimedia. Students with learning disabilities may find that there are hardly any online materials geared toward them at all. However, there are substantial improvements in assistive technology that can be integrated into hybrid learning to ensure equity and inclusion for these learners. Augmentative communication devices and Braille keyboards are available, as is accessibility-focused software, including text-to-speech and speech-to-text engines. Web browsers can now read text aloud, and wireless devices can transmit directly to hearing devices (*EdTech Magazine*, 2020). Captions and subtitles are widely used in video conferencing and applications. There are also reading tools and AI-powered applications for students with dyslexia, virtual reality tools to customize experiences for students with autism, and interactive displays and touch screens for those with fine motor challenges.

International experience shows that countries can take appropriate policy measures and implement programmes that cater for the most marginalized learners. The Republic of Korea is a promising case; Box 1 presents a concrete programme there targeting disabled persons.

Box 1. Spotlight on the Republic of Korea

Through the Priority Project for Education Welfare, the Ministry of Education in the Republic of Korea provided tailored support for vulnerable students. As a result, emergency supplies and learning packages were offered to students, and online learning was supported by providing digital devices and guidance on how to use them. By 2020, approximately 330,000 students from all 17 metropolitan and provincial offices of education had benefited from this service. Multicultural students were guided to use various online content, including video content for Korean language classes (222 classes in 2020; 96 classes in 2021). Not only that, the Central Multicultural Education Centre and its regional support centres across the nation worked together to develop parent notices in multiple languages to distribute to multicultural households. An 'online learning site for students with disabilities' was established. A total of 4,247 teaching and learning materials were produced for different types of disability needs, and the government covered the cost of data usage incurred by using the site. In particular, for students with disabilities who had difficulty participating in online classes, learning packages were provided that took into account the type and degree of their disability needs. Moreover, they were offered 1:1 or 1:2 in-person education (at school or home).

1.3 Opportunities and risks

As with any emergent practice that quickly becomes more widely adopted, certain opportunities and risks need careful consideration by decision-makers, educators, developers and other key stakeholders. This ensures the effective development and design of hybrid learning experiences and avoids the kinds of errors that may be incurred when programmes are planned in hasty or perfunctory ways. This section looks at some of the main opportunities and risks associated with hybrid learning approaches. They fall under six areas:

1. Equitable access
2. Flexibility of delivery
3. Pedagogies and learning environments
4. Content creation and customization
5. Roles of teachers and educators
6. Teachers' support and training

Opportunities/benefits	Potential risks
Equitable access	
Extending access to basic education: Costs can be low (if they are subsidized, if partnerships are established, and/or if sustainable funding sources are identified), meaning that hybrid learning potentially offers opportunities to lower education costs and increase access to learning materials. This includes new approaches and opportunities linked to formal education and skills training, qualifications, and higher education opportunities. **Extending access to non-formal and informal learning and supporting social learning within communities:** Hybrid learning can effectively support and extend non-formal and informal learning, for example in community, charity, volunteer, and interest groups. It can address multiple and broad learning requirements.	**Infrastructure, digital devices and bandwidth:** There is a huge range of options; how do we know what is 'best suited in a given context'? More importantly, there are still huge disparities in access to digital resources, online connectivity, and associated infrastructure. Development costs can be high, especially for augmented reality (AR) and virtual reality (VR). As a result, large numbers of learners may fail to reap the benefits, which would add another dimension to existing digital, educational and social divides. **Inequalities:** Access is unequal across learners (digital divide); languages (English dominates); types of company (by sector and size); and occupations. This poses the risk of accentuating existing inequalities within and across countries. There are differences in infrastructure, access, ownership, pedagogical and technical knowledge, and a range of other factors that mediate effective utilization.

Flexibility of delivery	
Flexibility for learners: Hybrid learning approaches offer great potential to make learning more flexible to suit the learner. Hybrid models decouple learning from time and place (especially online/remote/mobile) and decrease the rigidity of learning systems by providing students with flexibility in terms of when, where, and how to engage with learning. This enables them to study online, or face to face, according to their circumstances and preferences.	**Flexibility tempered by context:** In low-resource contexts, schools may have a small number of computers or tablets to distribute among students, limiting the types and frequencies of rotations that can be employed. Class sizes are often very large, and there may be upwards of 60 or even 80 students per classroom. When schools are crowded, there might be little to no additional space to run Flex or individual rotations, and the school day may be truncated due to second shifting. Climactic factors such as heat and dust quickly destroy computers, servers, and other hardware infrastructure, affecting the number of working devices in computer labs. **Flexibility tempered by learner preferences:** Learners will have different attitudes toward digital and online learning. Some may not enjoy it, while others might find the distance elements isolating, or simply not perform well in online or digital environments. **Maintaining engagement:** One of the main challenges of hybrid learning revolves around the concept of student engagement. In particular, it can be a challenge to keep the in-class and remote students as engaged as each other, in order to deliver an equal learning experience.
Pedagogies and learning environments	
Supporting pedagogical innovation: When hybrid experiences are affordable and well-designed, educators have the potential to incorporate a more varied set of pedagogical strategies to engage students in learning. Rather than replacing one method or approach to teaching, hybrid models can enable the introduction of additional or extension materials, and help customize learning experiences, approaches and pedagogies. This includes steering learners towards new, different experiences (multimedia), such as visualizing abstract content (especially AR, VR, and AI). It also allows teachers to give faster, more tailored feedback to learners.	**Weak attention to pedagogy and poor lesson design:** Poorly designed lessons can harm learning. Whilst this is true of any learning experience, the management of both digital and face-to-face elements can present educators with additional challenges. In some cases, learning technologies are utilized without adequate consideration as to whether they enhance the overall learning process, or without a clear pedagogical strategy underpinning them. **Potential bias of automated tools:** Online assessments may be biased against non-dominant vernacular languages and dialects (UNESCO, 2021e). Bias has serious ethical and equity implications; it affects the integrity of the conclusions drawn from the data, which can affect student outcomes.

Content creation and customization	
Customized and differentiated contents: Greater empowerment and autonomy for teachers and learners can result from the use of online learning materials and spaces. Educators can choose content that has been designed, collected, collated and customized specifically to personalize learning experiences and account for particular learning needs. This increases accessibility, especially for marginalized and at-risk groups, learners with specific educational needs, and others who may traditionally be under-represented in education and/or excluded from certain settings or forms of learning.	**Learning is not designed with learners in mind:** It is not uncommon for technological solutions to be introduced without consideration of the learners' readiness, abilities and skills and/or without accompanying strategies to support wider social and emotional needs. This may affect their well-being and development. Teachers may struggle with low literacy and/or absenteeism, making the acquisition of digital and advanced pedagogical training an even greater challenge. **Weak learning content:** There are numerous examples of online learning spaces and experiences that have been undermined by poor content and/or poor design of learning and teaching activities. Poorly designed experiences can demotivate learners, undermine pedagogical approaches and, in some cases, introduce confusion and create barriers to effective learning.
Roles of teachers and educators	
Providing new tools and approaches to learning: There is great potential to harness more dynamic, interactive, collaborative, and engaging digital technologies to support learners and bring learning to life. Hybrid models enable educators to rethink wider strategies for improving learning experiences and address the varied needs of more learners. **Expanding learning materials and possibilities:** If designed effectively, hybrid learning can foster learners' and educators' access to additional, rich learning materials. For example, these might supplement, consolidate, assess, extend or expand on in-person or distance learning activities, and be used to introduce content and tasks prior to or following taught elements.	**Educators are alienated from the process:** Hybrid learning presents an opportunity to engage educators in shaping new developments to support effective learning. However, new digital developments are often introduced without their input and imposed on them through policy or institutional requirements, without any discussion or debate about the professional and pedagogical implications for them and their learners. **Replacing educational institutions with technology:** There is some fear that the ubiquity and popularity of digital tools and AI will render educators unnecessary and institutions obsolete (UNESCO, 2021f). While such a shift has yet to manifest, it is important to underscore the irreplaceable role of the educator in the learning process, and the socialization and community roles that educational institutions play in the lives of learners.
Teachers' support and training	
New opportunities for teachers' professional development and training: Providing new digitally mediated learning opportunities may serve to enhance the role of the educator. If designed effectively and with educators engaged in the process, hybrid learning presents a great	**Teacher training and ongoing professional development programmes do not address the new skills needed in hybrid learning settings:** Teacher training may not prepare teachers to configure groups, spaces, contents and approaches across learners with different learning styles. They

opportunity for teachers to contextualize and redesign learning and teaching experiences to address their learners' needs. Opportunities also exist for teachers to be recognized and rewarded for their role in designing new learning experiences. They can work collaboratively in local, national and global communities of practice to share knowledge and address key challenges, although to do so effectively requires additional capacity in the system.	may also have difficulties resolving technical issues and overcoming disruptions during classes (e.g. noise, interference, and unstable connectivity) and mediating collaboration between in-person and remote learners when collaborating in traditional classroom settings. For example, learners can be physically placed into groups, but this is not viable when some students are learning remotely. Therefore, the combination of the two learning strategies presents an obstacle to collaboration. Teacher training needs to prepare teachers to overcome all of these challenges.

1.4 Conclusion

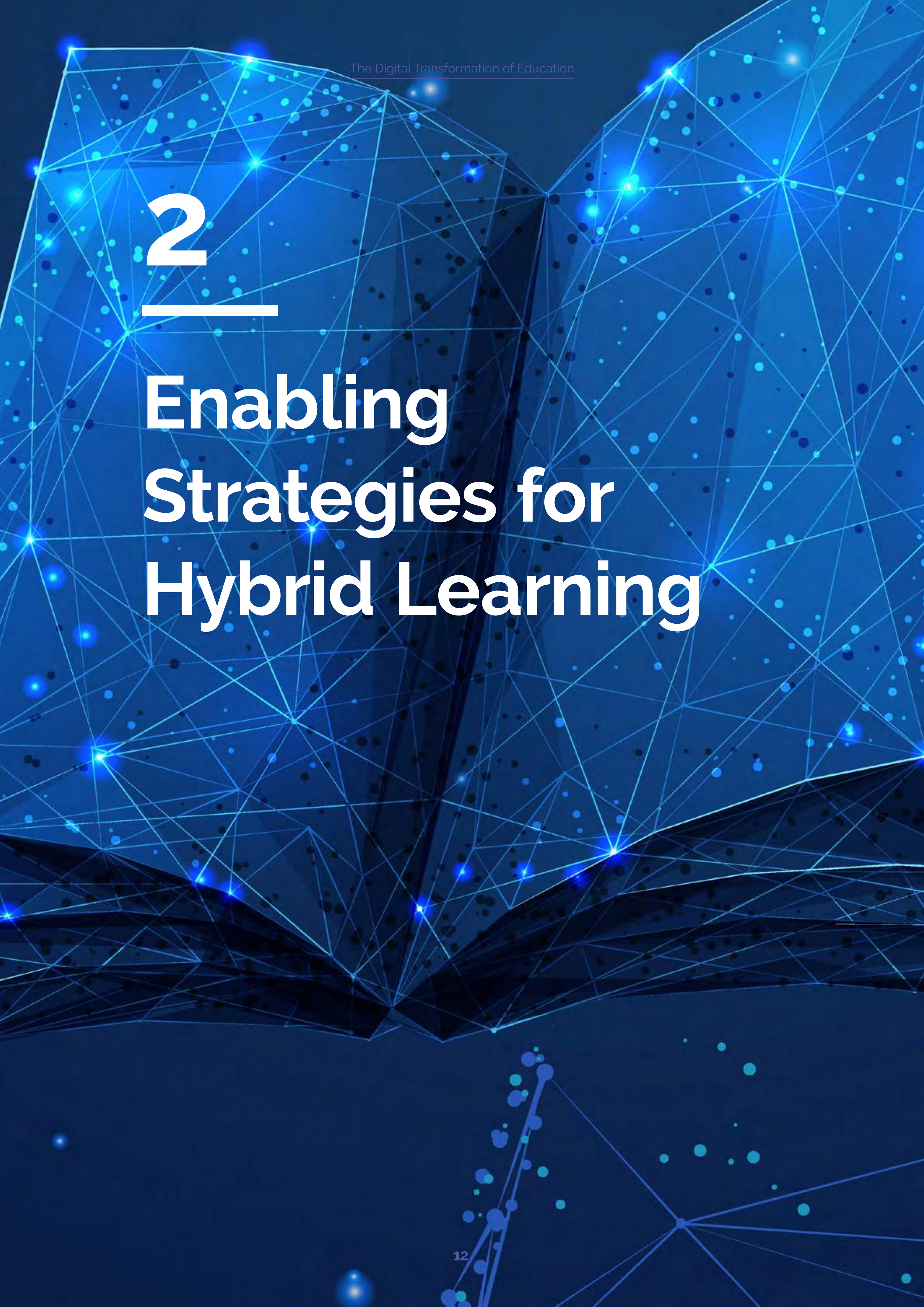
Hybrid learning has emerged as a common strategy and policy response across countries. Governments and other stakeholders have been using a wide range of technologies to strive for continuity of learning throughout the pandemic and integrate face-to-face instruction with online and/or computer-aided pedagogies.

Organizing hybrid or digital learning, first in a situation of emergency, then over periods of several months now extending across at least two academic years, has been a challenge for educational authorities. During and beyond the recovery, digital technology will have the potential to support innovative teaching within a lifelong learning perspective. In this context, it is worthwhile to think about the multitude of learning spaces with which educators can combine face-to-face and online or offline computer-aided instruction, including schools, vocational institutions, colleges, universities, workplaces, libraries, community learning centres, and homes. This hybrid learning approach, when adequately implemented, can address the challenges of delivering equitable, quality education and lifelong learning opportunities.

Therefore, governments and national stakeholders should decide which models of hybrid learning are the most appropriate and identify the contexts and situations where they may work best. The pedagogical focus should be on learner-centred, active and collaborative learning. Moreover, stakeholders should recognize the central role played by teachers and support staff as agents of change and give them adequate training. Ultimately, hybrid learning models, like their traditional counterparts, must be designed with a focus on inclusion and equity, prioritizing those who are most at risk of being left behind.

Governments and other stakeholders should remove barriers to hybrid learning such as problems with connectivity and capabilities. They should also mitigate risks to learners' data protection and security, and empower key actors such as teachers and educators.

In addition to instructional design and pedagogic factors, enabling strategies are required to fully unleash the potential of hybrid learning to recover from the pandemic and accelerate toward achieving SDG 4. This is discussed in the next chapter.



2

Enabling Strategies for Hybrid Learning

Chapter 2: Enabling Strategies for Hybrid Learning

To make hybrid learning a viable option, countries need to design and implement strategies across four areas: (1) an overall digital society approach, emphasizing digital skills for education, work and lifelong learning; (2) an infrastructure and connectivity plan targeting education and training institutions that aims at overcoming the digital divide; (3) a digital transformation for teaching and learning; and (4) a self-sustaining funding plan, as hybrid learning comes with costs that make it a challenge for both governments and families, especially in low-income settings.

2.1 Fostering the transition toward digital societies and economies

2.1.1 National ambitions and policies for digital transformation

Just as public services are now affected by access to digital technologies, the latter have also transformed national economies and the world of work. Members of today's workforce will need to learn new skills over the course of their lives to continually adapt as new occupations emerge. The COVID-19 pandemic has no doubt accelerated this transformation in high- and low-income countries alike (McKinsey, 2021).

But long before the novel coronavirus became a mainstay of global discourse and our collective vocabulary, many countries around the world had begun to lay the foundations for their transformation towards digital societies and embarked on ambitious economic reform agendas to improve their competitiveness, business conditions and productivity.

Dedicated actions include the elaboration of national digital transformation strategies and digital skills policies, framed as stand-alone policies or integrated into medium- to long-term national development plans (examples cited directly in this report include Brazil, Egypt, Estonia, India and Nigeria). They also include punctual investments and digital literacy drives to improve infrastructure, boost the uptake of digital services, and promote digital literacy even further. The Digital India campaign, for example, has sought to improve online infrastructure and increase internet connectivity to ensure that government services are delivered virtually.

Such measures recognize the importance of digital policy to a country's economic trajectory and strive towards digitalization across national territories, aiming to bolster the infrastructure that will enable the public sector, civil society and private sector to access and leverage digital services in urban, rural and outlying areas. They also factor in the need for investment in, and incentives to use, ICT infrastructure that will scaffold digitalized public services so that both providers and beneficiaries can access services efficiently.

In Brazil, for example, there has been a more concerted focus over the past decade on incentives for low-income citizens to use digital services. This includes the central bank's rollout of an instant payment system that can be easily accessed on mobile phones to boost digital finance, as well as a recently approved legislative framework for start-ups that is expected to ramp up the economic impact of the digital sector. In India, the government has encouraged faster acceptance of digital payments among businesses and online services, with its demonetization policy (where 86 per cent of all active currency in circulation was deemed invalid overnight) as the stick to accelerate progress. For both of these initiatives, people must of course be digitally literate and able to use mobile applications. But together, the combination of investment in infrastructure and skills alongside these more market-based trends is expected to deepen these countries' digital skills bases over time.

Digital policies also take into account the strategic importance of the Sustainable Development Goals and their Global Indicator Framework on all development policies, including SDG Indicator '4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill' and earmark investments for digital skills development and the digitalization of education systems more broadly. Such investments support flexibility and pedagogic innovation through blended and hybrid forms of learning (including issues related to access, the creation of content and the professional development of the education workforce), as well as digital skills training and lifelong learning that will facilitate learners' entry into in-demand sectors of the labour market.

In low- and high-income countries alike (including Australia, Brazil, Egypt, India, and Nigeria), until very recently, governments' approaches to strengthening infrastructure and addressing digital skills gaps were most often supply-based to mitigate shortages of digital access and connectivity outside of major urban centres and in poorer or more remote locations. The view is that until the access gap is closed, the skills gap itself will persist. While much progress has been made, the fast-changing digital landscape poses a risk of widening the digital divide if countries do not address digital knowledge and competency needs (on the demand side) to foster opportunities for shared prosperity. Vietnam (see Box 2) is an inspiring case where the government identified skills development as an important component of its digital transformation strategy.

Box 2. Spotlight on Vietnam

Vietnam has developed rapidly in recent decades. Major economic reforms, known as Doi Moi, began in 1986 but accelerated after the country's accession to the World Trade Organization in 2007. Between 2002 and 2018, GDP per capita nearly tripled, lifting more than 45 million people out of poverty and transforming Vietnam into an export-oriented manufacturing powerhouse that has been supplemented by rising domestic consumption.

Despite decades of sustained economic expansion, the country's digital infrastructure, access, and skills base remained underdeveloped. It was only in 2016 that the government identified digital skills development as an essential attribute for future economic competitiveness. The pandemic, however, exposed persistent weaknesses in Vietnam's digital infrastructure, which has limited digital payment options and poor network security.

2.1.2 Assessing digital maturity

The capacity of countries and their institutions, public services, and corporate and business communities to successfully absorb new initiatives and integrate the changes needed for digital transformation will depend on their level of digital maturity. Targeted models or 'readiness' tools and rubrics support governments and organizations in assessing their digital maturity level according to pre-defined parameters, dimensions or indicators. These models can also assist in bringing about a more systematic understanding of the current state and the capabilities of an organization to effectively manage and guide digital transformation efforts. In short, digital maturity models look at dimensions and criteria to describe measures or areas of action which indicate an evolutionary path towards digital or AI maturity (Teichert, 2019).

Several rubrics or frameworks have been developed by think tanks and the foresight and intelligence units of international corporations, intergovernmental organizations and private sector actors (see Table 2). They often gather and analyse countries' governance capabilities at a large scale, using a combination of hard data with survey-based information.

There are nonetheless differences in focus among the various models or indices. For example, KPMG's Change Readiness Index measures a country's overall preparedness for any type of transformation. It splits the measurement into three dimensions – enterprise; government; and people and civil society – emphasizing the critical role of human capacity and processes to support and sustain systemic changes, regardless of their nature.

The general AI Automation Readiness Index developed by *The Economist*, and the Oxford Insights Government AI Readiness Index, focus more on countries' digital readiness rather than usage or impact maturity. They both highlight the institutional frameworks capable of change and innovation, as well as legal and ethical frameworks.

An example that focuses directly on the distribution of internet access is the Inclusive Internet Index. It looks at affordability, relevance and skills readiness alongside access, to help us better understand how inclusively the internet is being distributed and used. Other indices might home in on the development of human capital, including 21st century and digital skills.

In general, they all lead to the production of aggregates that allow for international comparison, enabling analyses of progress at the individual country level and confirmation of the existence of digital divides between countries depending on per-capita income levels.

Table 2. A sample of rubrics and assessments of digital maturity

Roadmaps	
Roadmap for Digital Cooperation	This roadmap was presented by UN Secretary-General António Guterres during a high-level virtual event on 13 June 2021. It follows the work from the High-level Panel on Digital Cooperation established in 2018 and has eight areas of focus: connectivity, digital public goods, digital inclusion, digital capacity building, digital human rights, digital trust and security, critical infrastructure, and global digital cooperation.
Maturity models, rubrics and indices	
Automation Readiness Index	Developed by ABB and *The Economist*, the Automation Readiness Index surveyed and ranked 25 countries on their automation readiness, meaning their ability to integrate AI and robotics-based automation into their economies, businesses and workforces.
Digital Planet's Digital Evolution Index (DEI)	This is a data-driven study of the pace of digital growth across four key drivers that govern a country's evolution into a digital economy: demand conditions, supply conditions, institutional environment, and innovation and change.
KPMG Change Readiness Index	This index measures a country's overall readiness for any type of transformation.
Government Artificial Intelligence (AI) Readiness Index	Oxford Insights and the International Research Development Centre publish the AI Readiness Index which measures governments' preparedness to implement AI in the delivery of public services to their citizens.
The Inclusive Internet Index	Commissioned by Facebook and developed by *The Economist*'s Intelligence Unit, the Index seeks to measure the extent to which the internet is not only accessible and affordable, but also relevant to all, allowing usage that enables positive social and economic outcomes at the individual and group level.
Reports on digital readiness	
Global Information Technology Report	This report was produced as a collaboration between INSEAD, the World Economic Forum, and the World Bank. It ranked the world's economies in terms of networked readiness and effects on economic growth and productivity.[5]
ITU Digital Development Dashboard	The Digital Development Dashboard provides an overview of the state of digital development around the world based on ITU data. The information is collected annually and viewable by country under the categories of 'Infrastructure and Access', 'Internet Use', and 'Enablers and Barriers'.

5 Please note that the 2016 Global Information Technology Report is the last edition of the series. No further updates are available at the time of writing.

Measuring Digital Development (MDD) series (replaces the Measuring the Information Society Report)	The MDD series includes Measuring Digital Development: Facts and Figures and Measuring Digital Development: ICT Price Trends (and also Telecommunication/ICT Indicators). It replaces the MISR, an annual report published by the ITU starting in 2009 which featured key ICT data and benchmarking tools to measure the information society, presenting a quantitative analysis and highlighting new and emerging trends and measurement issues.

- *What do they show?*

Many of the current indices looking at digital readiness are dominated by countries with already strong economies, good governance, and innovative private sectors. They suggest that digital maturity is highly correlated with per-capita income, and the more mature and diversified an economy is, the likelier it is to have suitable infrastructure, institutions, regulations and human capital. This creates a virtuous cycle of digital development.

The digital divide becomes apparent from several reviews and reports, including *The Economist*'s Automation Readiness Index and the Oxford Insights Government AI Readiness Index, as well as those covering digital technologies more broadly such as the ITU's Measuring the Information Society report, the Digital Planet's Digital Evolution Index (DEI), the World Economic Forum's Global Information Technology report, and the Cambrian Group's AI Readiness Index.

Low- and lower-middle-income countries in general face a greater challenge than upper-middle and high-income countries, and will need adequate support from the international community. Here, progress in digital skills development has been uneven — whether concerning the basic skills required to participate in an increasingly digital society or advanced skills that can equip workers to compete for high-tech jobs.

Even in middle- to higher-income countries, for example the 27 countries of the European Union, digital maturity and the digital skills challenge is not evenly spread. There are regional and socio-demographic differences in digital infrastructure, literacy, and skills. While some Member States, primarily in western and northern Europe, are saturated with internet access and have higher rates of basic digital skills, the rest of the EU, including Bulgaria and Romania, still have significant ground to cover.

In relation to the impact of digital transformation on income inequality, the 2020 Network Readiness Index, which ranks countries on various digital transformation metrics, revealed that while most countries with greater access to the internet have relatively more income equality, there are some outliers — mostly among large emerging market economies. Brazil is an example: it is far ahead of the developing world in terms of internet penetration, but this progress has not narrowed the income gap (perhaps due to vast ICT skills disparities within the general population).

Given the state of play, there is a growing concern about digital divides within and across countries and the lack of attention to holistic, comprehensive and sustainable strategies that go a step further than simply increasing access to digital infrastructure and services. There are increasing calls for countries to situate their digital transformation ambitions within broader national development and education sector goals and ecosystems, and prioritize strategies that accelerate progress towards poverty reduction, economic mobility, social equity and digital inclusion.

2.1.3 Investing in human capital through digital skills policies

Research and analysis suggest that a rising number of governments recognize the significance of investing in digital skills and inclusion to support societal transformation – specifically to support the uptake of digital services, R&D investment, new job creation, and economic growth. As indicated above, national authorities have invested significant sums in improving digital infrastructure, as well as digital literacy training policies and campaigns. Countries such as Egypt, India, Nigeria and Vietnam (see Box 3) adopted overarching strategies and flagship programmes covering investment in human capital. To accomplish digital goals, officials in these countries and others have sought to leverage partnerships with telecoms and private sector technology companies as well as international technical and financial partners. In most cases, however, these are top-down programmes decided and governed centrally and then implemented at local levels including within companies for workforce development.

Box 3. Spotlight on digital policies in Egypt, India, Nigeria and Vietnam

In **Egypt**, authorities have prioritized digital skills policies and development since the early 2000s, when it was seen as a way to reduce joblessness by providing young people with skills for employability. Digital skills development now forms a key pillar in Egypt's Vision 2030 strategy, launched in early 2016, with the government relying on technology and digital transformation to meet two of eight objectives: a competitive and diversified economy; and knowledge, innovation, and scientific research.

Digital Egypt was launched in 2019 with the goal of transforming the country into a digital society, with three major focus areas: digital transformation, digital skills, and digital jobs. Basic digital skills development programmes were launched in April 2020 to empower citizens by increasing their digital capabilities. The government has also partnered with international tech companies such as IBM, Cisco, and Microsoft through its Digital Egypt Builders Initiative to deploy the country's top engineering and computer science graduates. Other examples of public-private collaboration are the alliance between telecom provider Orange Egypt and Germany's international development agency GIZ to establish a digital training centre in late 2021. In February 2021, officials announced plans to establish an additional six technological universities throughout Egypt, adding to those already operating in New Cairo, Quesna, and Beni Suef.

In **India**, the government launched a digital literacy initiative in March 2014 that eventually became the National Digital Literacy Mission (NDLM). The NDLM was then linked to the Digital India campaign, and began by training one million people within 18 months (on a budget of $12.1 million). In January 2015, the government rebranded NDLM as Digital Saksharta Abhiyan (DISHA). DISHA began with an allocated budget of $47.3 million and aimed to train 5.25 million citizens in four years. Convinced of the success of the programme, authorities in 2017 launched Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA), which aimed to train 60 million people by 31 March 2019, and had an even larger budget of $320 million. The government's main partner is the NASSCOM Foundation, which is the social arm of the IT/BPO trade association. NASSCOM designs the content and curriculum for these courses, while companies such as Google, Microsoft, and Intel provide funding for the centres. Various NGOs, including Muskan and IT for Change, have partnered with the government to provide services.

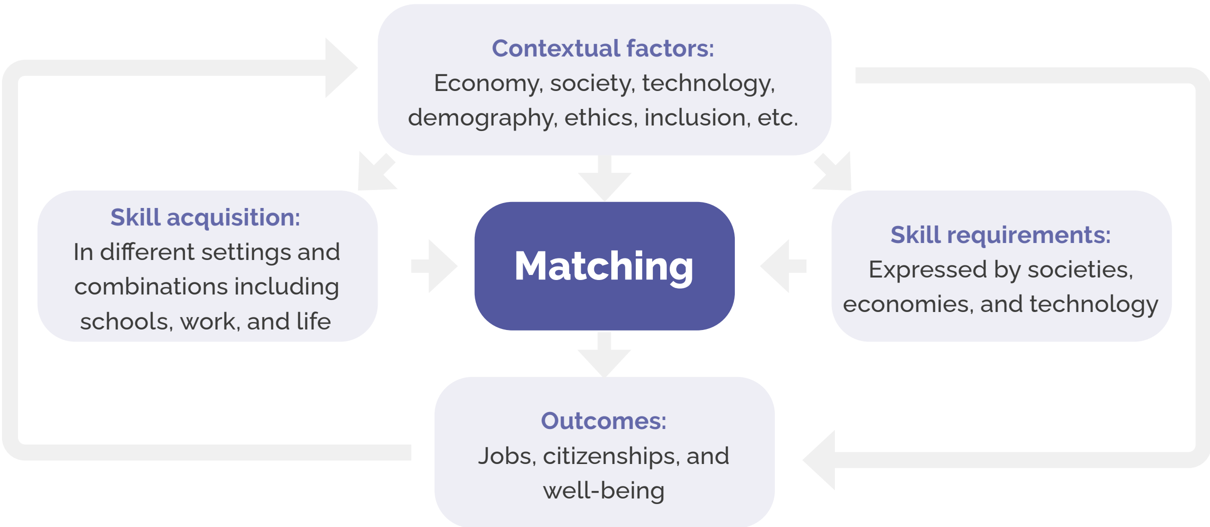
In **Nigeria**, the NIP aims to close gaps in creative and technology industries by generating more innovation and jobs. A $500 million fund backed by the government and its partners, primarily the African Development Bank, is expected to be set up to support the initiative. The Human Capital pillar of the programme proposes support for digital upskilling initiatives that will train a cumulative two million people in basic, intermediate, and advanced digital skills.

In **Vietnam**, digital skills development has been featured in various master plans that are supposed to provide an overarching view of the government's strategy. For example, in the National Strategy on the 4th Industrial Revolution by 2030, approved in late 2020, the Ministry of Industry and Trade was tasked with establishing programmes that promote high-tech human resources for Industry 4.0. In addition, the Ministry of Labor, Invalids, and Social Affairs is responsible for improving vocational training in IT skills, as well as creating retraining programmes for workers transitioning into jobs requiring digital skills. Separately, the National Digital Transformation to 2025 towards 2030, issued by the Vietnamese government in 2020, also emphasized the need for skills training, including the retraining of workforces in industrial zones.

The pandemic further demonstrated the importance of the ICT sector for national economies, with governments swiftly moving to deal with increased demand for ICT services and accelerating the digitalization of their public services. But with the rapid shift to remote work, developments during the public health emergency have super-charged shifts in thinking, attitudes and behaviours at every level in relation to the place of digital skills in our lives.

In 2020, government leaders and decision-makers were forced to see digital skills policies in a more holistic light, looking at all of the significant contextual factors, enablers and building blocks of digital ecosystems, as well as the potential outcomes for citizens and their jobs, education and well-being, particularly where educational goals and digital policies intersect. Figure 2 provides an overall framework which makes clear that a range of factors are required to ensure a successful strategy.

Figure 2. Components of a national policy for digital skills development



Leaders in every economic sector were also pushed to prioritize skills development and technologies that allow remote teams to continue working together and collaborating effectively during the lockdowns. Upskilling was a priority for many organizations and corporations before the pandemic, but it is evident that it has now become an economic imperative. Investing in human capital and digital skills is thus foundational to economic policy and sustainable recovery from the COVID-19 crisis. To facilitate governments' and organizations' understanding of the digital skills needed to thrive in modern societies, many skills development frameworks have been developed over the past two decades.

2.1.4 Identifying and assessing skills through digital skills frameworks

A variety of frameworks have been developed that attempt to organize the complexity and range of digital skills perceived as essential in today's world. These are useful for countries in the design and implementation of national digital skills strategies for education, work and lifelong learning. Their importance has been embedded into instruments for collecting data on progress towards the Sustainable Development Goals (SDGs), particularly SDG Target 4.4 which declares that '*By 2030,* [countries will] *substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship*' and the accompanying indicators 4.4.1 '*Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill*' and 4.4.2 '*Percentage of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills.*'

Digital skills assessments generally follow three steps: (1) assessing the digital skills levels of education and training system stakeholders; (2) building a framework to identify skills that are key to hybrid learning, and related skills shortages; and (3) adopting a national policy for digital skills development that takes hybrid learning requirements into account. Within such assessments, skills are usually measured along a continuum and arranged into proficiency levels. They allow governments, firms and training providers to identify and assess skill levels among students, trainees or employees and offer relevant capacity-building programmes.

Digital skills frameworks have been developed at global, regional, sub-regional and national levels; their featured criteria, competencies and rubrics vary depending on their purpose, and on the socio-economic and cultural contexts for which they are intended. The International Telecommunication Union (ITU) underlines the importance of carrying out national digital skills assessments as part of countries' digital policy and framework development. Its digital skills classification is included in the ITU Digital Skills Toolkit while the ITU Digital Skills Assessment Guidebook is a useful tool for governments which intend to organize digital skills assessments.

Certain general frameworks are useful as a synthetic overview of the digital skills necessary to succeed in the workplaces of the future, for example the World Economic Forum's Global Skills Taxonomy (2021). Corporations have also produced their own skills frameworks to scaffold workforce development and growth through upskilling and reskilling. Box 4 provides a brief description of Ericsson's common skills-based language and taxonomy.

Box 4. Ericsson common skills-based language and taxonomy

Ericsson has strategically invested in workforce development and growth over the next decade by redefining its learning and development strategy, set-up and delivery model and creating a common skills-based language and taxonomy, making it clear what each skill means. This framework enables the benchmarking of workers and people against critical skills. A combination of assessments is possible: some are self-assessments; some use an assessor and have people demonstrate their contributions; and some involve project-based knowledge. Once people know their skill level in a particular area, getting to the next level requires gaining new credentials, including micro degrees through university partnerships; real-world projects; or experiential, hands-on, lab-based learning for deliberate practice. Data analytics measure progress and make it visible and accountable through skill dashboards. They also make it easy for people to see and share their skill progression profiles, to discover assignments and new job opportunities.

In labour markets that are more automated, digital, and dynamic, McKinsey (2021) also completed research on the foundational skills that are considered appropriate to enable citizens to: (1) add value beyond what can be done by automated systems and intelligent machines; (2) operate in a digital environment; and (3) continually adapt to new ways of working and new occupations. They include four broad skill categories — cognitive, digital, interpersonal, and self-leadership — and 13 separate skill groups belonging to those categories (see Figure 3).

Figure 3. McKinsey's (2021) 56 distinct elements of talent (DELTAs)

Cognitive

Critical thinking
- Structured problem solving
- Logical reasoning
- Understanding biases
- Seeking relevant information

Planning and ways of working
- Work-plan development
- Time management and prioritization
- Agile thinking

Communication
- Storytelling and public speaking
- Asking the right questions
- Synthesizing messages
- Active listening

Mental flexibility
- Creativity and imagination
- Translating knowledge to different contexts
- Adopting a different perspective
- Adaptability
- Ability to learn

Interpersonal

Mobilizing systems
- Role modeling
- Win–win negotiations
- Crafting an inspiring vision
- Organizational awareness

Developing relationships
- Empathy
- Inspiring trust
- Humility
- Sociability

Teamwork effectiveness
- Fostering inclusiveness
- Motivating different personalities
- Resolving conflicts
- Collaboration
- Coaching
- Empowering

Self-leadership

Self-awareness and self-management
- Understanding own emotions and triggers
- Self-control and regulation
- Understanding own strengths
- Integrity
- Self-motivation and wellness
- Self-confidence

Entrepreneurship
- Courage and risk-taking
- Driving change and innovation
- Energy, passion, and optimism
- Breaking orthodoxies

Goals achievement
- Ownership and decisiveness
- Achievement orientation
- Grit and persistence
- Coping with uncertainty
- Self-development

Digital

Digital fluency and citizenship
- Digital literacy
- Digital learning
- Digital collaboration
- Digital ethics

Software use and development
- Programming literacy
- Data analysis and statistics
- Computational and algorithmic thinking

Understanding digital systems
- Data literacy
- Smart systems
- Cybersecurity literacy
- Tech translation and enablement

Other frameworks offer a summary of the digital literacy skills necessary for people to become empowered citizens, for example the Digital Intelligence framework (DQ Institute, 2019).

Most national skills frameworks are referenced to basic education and technical and vocational education and certification. Here the most frequently mentioned competences are hardware and software operations, information and data literacy, interacting through digital technologies, developing digital content, and protecting personal data and privacy. To this end, the European Commission's Digital Competence Framework for Citizens (DigComp) and the extended version provided in 2018 by UNESCO in the Digital Literacy Global Framework (DLGF) have been most widely used by governments and corporations to design curricula and training programmes. The Broadband Commission's Digital Framework (2017) offers a simpler categorization of digital skills. A number of examples are given in Table 3.

Table 3. Major digital skills frameworks

Global Frameworks	Organization	Year
OECD Digital Skills Framework	OECD	2016
Digital Skills Framework	Broadband Commission	2017
Digital Competence Framework for Citizens (DigComp 2.1)	European Commission	2017
Digital Literacy Global Framework (DLGF)	UNESCO	2018
UNESCO ICT Competency Framework for Teachers	UNESCO	2018
Children's Skills Framework	UNICEF	2019
Digital Intelligence Competencies	DQ Institute	2019
Data Skills Framework	ODI	2020
Global Skills Taxonomy	World Economic Forum	2021
National Frameworks		
Basic Digital Skills Framework	UK Government	2018
Digital Citizen Education Framework	Council of Europe	2019
Digital Literacy Skills Framework	Australian Government	2020

Again, research suggests uneven progress in the promotion of digital skills across countries, in terms of both the basic skills required to participate in an increasingly digital society, and the advanced skills that can allow young people entering the workforce to compete for high-tech jobs. A combination of policies, directives, investments, incentives and partnerships will be needed that address different dimensions of digital ecosystems and education and training systems in tandem (including governance, infrastructure, delivery, certification, and funding). These will need to be framed against bigger-picture investments that target the root causes of, and seek to address, the digital divide within and across countries.

2.2 Overcoming the digital divide

An element that lays the groundwork for hybrid learning approaches is the attention given to investments in infrastructure, access to devices, coverage and increasing usage within the hybrid learning ecosystem (also see section 2.4. for a focus on financing). But these investments must be set within discussions around the digital divide, equitable provision, and affordability.

While many positive trends are noted – i.e. internet usage continues to grow globally, with 4 billion people, or 51 per cent of the global population now using the internet, and mobile broadband coverage now reaching 93 per cent (ITU, 2020) – there remain stubborn obstacles to full coverage and usage within and across countries, particularly in rural and remote areas. Perhaps more importantly, there are many human, socio-economic and demographic challenges to overcome before digital societies and fully integrated hybrid learning can become realities.

This section takes a closer look at the hardware and technical issues that will need to be tackled as countries prepare their hybrid learning strategies.

Infrastructure and access to the internet and devices: Estimates suggest that $428 billion would be needed to achieve universal access to broadband connectivity globally by 2030. This works out to $40 billion a year on average. Technologies involved include 4G, 5G, satellite, WISP, and/or fibre, each with distinct advantages and disadvantages in terms of capacity, latency, scalability and costs:

- **Fibre:** In terms of capacity, fibre's characteristics allow for stronger performance vis-à-vis other connectivity methods, as it can support more than 10 Gbps. In addition, it has the lowest latency. It is especially suitable for dense urban and long-haul applications, but may prove to be more expensive to extend to low-density areas. The scaling of local capacity is relatively easy, only requiring minor incremental updates.

- **Local WISP-operated networks:** A wireless internet service provider (WISP) allows subscribers to connect to a server at designated hot spots (access points) using a dedicated (high-speed) microwave backhaul connection to a fibre network which can be up to 25 km away. WISPs are important in closing the digital divide, as areas where fibre would expensive can be serviced with easy-to-install microwave radios. In addition, the set-up is affordable for communities in both rural and urban settings.

- **4G:** The capacity of 4G allows for speeds of up to 300 Mbps and even beyond (e.g. with Gigabit LTE), though in practice, speeds of 100 Mbps are more common. With 4G, latency times have been reduced from 120 ms (3G) to ~40 ms (4G), thereby providing medium latency. 4G is particularly suitable for suburban and rural areas, with the buildout of new areas preferably using low and mid bands. For urban areas it is suitable if a significant amount of spectrum is activated and preferably 'quality of service' guarantees for schools are in place. In terms of scalability of the solution, it is highly dependent on the spectrum available in the respective area.

- **5G:** The capacity of 5G enables it to be substantially faster than 4G LTE. Latency times have been reduced further. Coverage thus far remains relatively limited but this technology can be central to digital learning and connectivity. The uptake of 5G has been rapid; despite a global pandemic and economic challenges, its subscriber numbers are growing at four times the speed of 4G's subscriber growth (5GAmericas, 2021).

- **Satellite:** The capacity of satellite is low to medium, with a maximum of up to 150 Mbps. Latency differs between satellite types, with GEO having a low latency at more than 500 ms, whereas LEO (e.g. Starlink) has a latency of 20-40 ms. Satellite systems can provide coverage to entire countries. Contrarily however, the scaling of local capacity is very difficult, requiring high density of satellites. Whereas GEO has a wide, but fixed coverage, therefore not allowing well for the buildout of new areas, Starlink, once launched, has global coverage.

Coverage: Despite the investments, a network coverage gap remains. Notwithstanding the global awareness about the importance of the internet and broadband connectivity, and their links to education and socio-economic progress, seven per cent of the population still does not live within areas that have network coverage (ITU, 2020). The heterogeneous geography of broadband infrastructure and investment results in variable service provision. As a result, large disparities exist in both access and performance within different geographic locations. Taking into consideration equity, and focusing on fairness and inclusion, experts recommend avoiding differentiation between harder- and easier-to-connect areas when it comes to equipping schools. In terms of minimum bandwidth for meaningful school connectivity, no differentiation should be made.

Large divergences exist among developing nations' abilities to acquire meaningful connectivity with their current infrastructure. Boxes 5 and 6 provide analyses of a wide range of contexts and challenges regarding universal connectivity.

Box 5. Spotlight on connectivity in low-middle income countries

In **Rwanda**, 98 per cent of the land mass is covered by a 4G network. However, only 22 per cent of the population use the internet on a regular basis. This gap is driven by several factors, such as digital literacy, electrification, affordability, and outdated devices. In addition to 4G, Rwanda has invested in expanding its fibre network by 45 per cent since 2015, spanning 6,100 km of backbone in 2019. Nearly all schools are within 30 km of the fibre network and covered by mobile broadband (Giga, 2021). In rolling out mobile broadband, Rwanda chose a unique path to 4G by providing a single licence to RTN in partnership with Korea Telecom Rwanda Networks (KTRN). Capacity is subsequently leased to commercial operators (MTN and Airtel). Differing views exist regarding the success of the programme in achieving meaningful connectivity due to the cost of the 4G services; for example, 1.5GB data-only mobile broadband costs about seven per cent of GNI per capita (ITU, 2020; KT Rwanda, 2021).

In **Honduras**, although 4G now covers many communities, a large portion of the population (68 per cent) remains unconnected. The country has however added to its national fibre backbone with 70 per cent of the population living within a 25 km range of the network. Unfortunately, regardless of the connection in place, a staggering 96 per cent of Honduran primary and secondary schools currently lack access to the internet. Moreover, 44 per cent of schools are not connected to electricity, further complicating the use of the internet.

Sierra Leone has not yet rolled out an extensive 4G network (35 per cent of the population is covered). While 86 per cent of schools are within 3G coverage, only 205 schools are connected. Although telecom players have been expanding their 4G networks in urban areas, rural areas are still lagging behind. Less than one per cent of the population is covered by a fibre network, so Sierra Leone has been investing in a national network. It is currently undertaking a $28 million fibre optic project to roll out 660 km across the country (Giga, 2021).

Despite the large penetration of mobile services throughout Brazilian society, there is still inequality of access, especially in its northern and north eastern states. In **Brazil**, ~88 per cent of the population has 4G coverage, but less than 10 per cent of the country's surface is covered with a 4G signal (mainly the high concentration of people around cities). Around 135 million Brazilians use the mobile internet (~70 per cent of the population). In the last few years however, significant progress has been made. In relation to telecommunications infrastructure, the fibre optic backbone network that served ~48 per cent of the municipalities in 2015, served ~82 per cent in 2020, reaching 4,582 municipalities. The current fibre optic backhaul network connects municipalities that represent ~96 per cent of the Brazilian population. But there are 988 unconnected municipalities, most of them in the northern and north eastern regions.

In **Indonesia**, mobile internet is widespread and the connectivity rate is over 130 per cent. Compared to other Asian nations, however, the fixed segment has low penetration rates with as little as 14 per cent of households subscribing to this service. The country's geography, consisting of 17,000 islands, is an obstacle for deployments that have focused on fibre. In 2015 there were only 1.1 million connections. After five years, the number of households with fibre reached almost nine million and fibre took up 80 per cent of the fixed-broadband market share by 2021. The regulator launched various initiatives to improve the capacity and reach of fixed-broadband services. The five-year plan, publicized in 2019, aimed at providing a 20 Mbps service to 30 per cent of the population, including 71 per cent of urban households. Even with the extensive mobile and smaller fixed broadband together, the coverage gap is significant: 13 million people across 12,500 remote villages have no access to the internet. According to the Education Ministry, more than a third of Indonesian students have limited or non-existent access.

In the mobile segment in **Nigeria**, despite LTE being the fastest-growing technology and recording 55 per cent growth since 2018, 3G is the dominant technology, accounting for 73 per cent of mobile data traffic in 2020. In the fixed-broadband segment, however, penetration is still very low, with less than one per cent of the population having subscriptions. Hence, the government pledges to deploy 18,000 km of fibre to extend broadband to rural areas. With its National Broadband Plan 2020-2025, it is aiming to deliver 70 per cent broadband penetration, up from 30 per cent in 2018. Despite the fact that it largely depends on mobile infrastructure, the government also aims to extend fibre-based broadband services to ~25 per cent of primary schools and ~50 per cent of secondary schools. The amount of investment needed to provide universal broadband service is challenging though. The country's backhaul fibre network, comprised of more than 40,000 km, needs to triple to at least 120,000 km.

Box 6. Challenges in reaching universal connectivity

In **Brazil**, a vast area of the country is unequipped with fibre, or another mode of internet connectivity. Especially in hard-to-reach areas, such as parts of the Brazilian Amazon, fibre and 4G are non-existent. Though 85 per cent of the population is covered with 4G, this constitutes only ~10 per cent of the entire land area. In addition, about 45 million homes are passed in Brazil using fibre. This means that ~76 million people lack access to a fibre network (although with the upcoming 5G spectrum auction, a conscious trade-off has to be made vs fibre).

Though more than 95 per cent of **Rwanda's** land area is covered by a 4G network, only nine per cent of the population uses it. This is mostly because of the high cost of using the network. Spending on data-only mobile broadband (1.5GB) as a percentage of gross national income (GNI) per capita was about seven per cent in 2019. This puts Rwanda in the top 30 least affordable countries for internet access. Whereas the average spent per capita as a percentage of GNI is ~3.4 per cent, the ITU's recommendation for affordable internet is two per cent.

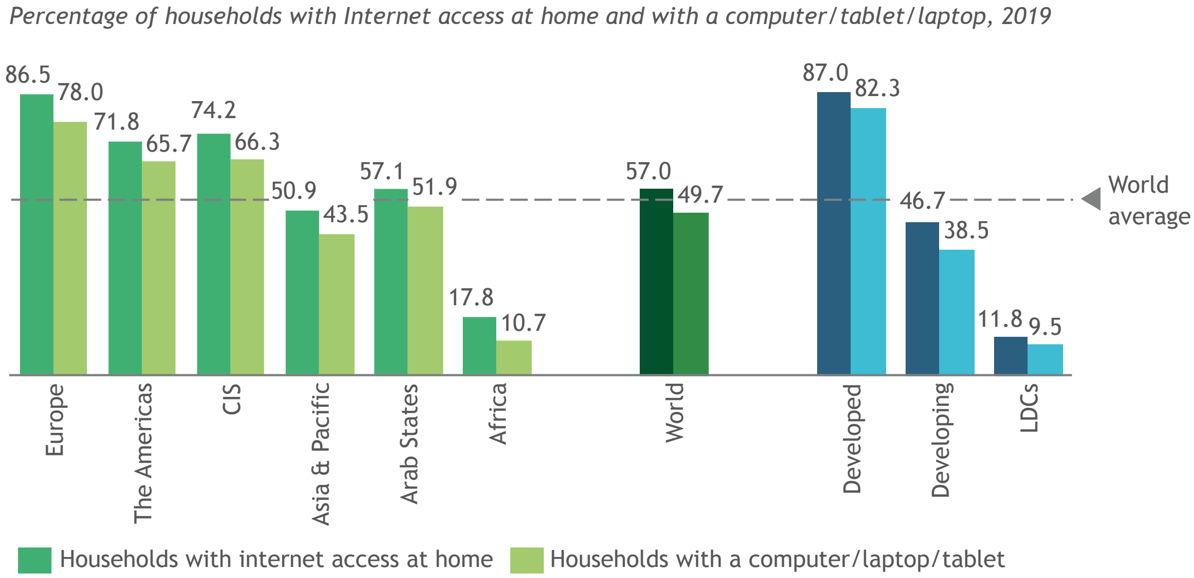
Sierra Leone's mobile internet coverage is 86 per cent, yet internet use remains low at 17 per cent. This is partly due to an unreliable power supply, with only 23 per cent of the population having access to electricity. Secondly, the cost is high, as ~16 per cent of GNI per capita would have to be spent on data-only mobile broadband for 1.5GB. Again, this is much higher than the ITU's recommendation of two per cent.

In **Nigeria**, only 47 per cent of the population are internet users, even though the mobile network (at least 3G) is used by 78 per cent. This is driven by the low penetration of electricity (accessed by only 55 per cent of the population), high illiteracy rates (38 per cent of the population is illiterate), and high poverty rates (which can be as great as 80 per cent of the population in some states).

In **Honduras**, only larger cities are covered by 4G, connecting 67 per cent of the population but just a fraction of the land area. Even so, only about 47 per cent use this network, leaving a usage gap of about two million people.

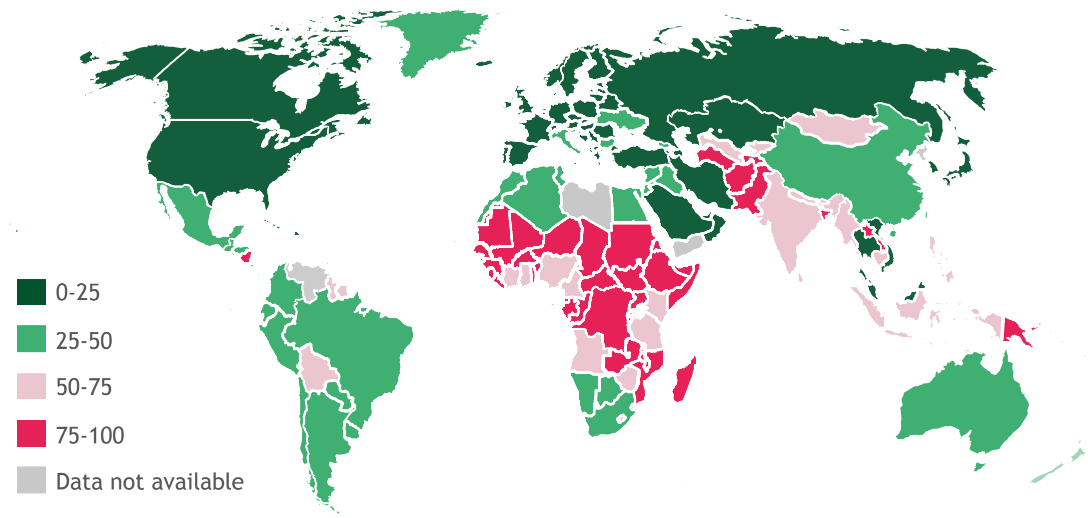
Access: Figure 4 pivots the analysis to look at access to the internet and appliances between continents and across development statuses.

Figure 4. Households with internet access and a computer at home per development status



Usage: As shown in Figure 5, even where there is internet coverage, this does not necessarily translate into internet use and the available data reveals significant gaps in usage: 40 per cent of the world's population live within range of a mobile signal but nonetheless do not make use of it (ITU, 2020).

Figure 5. Percentage of people not using the internet per country

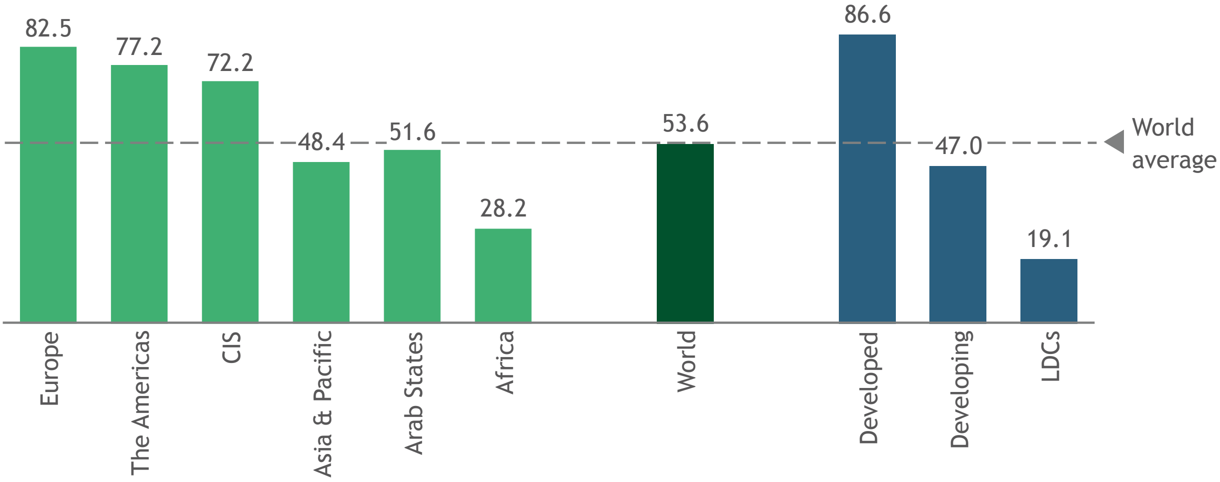


Note: ITU estimate
Source: ITU

An estimated 3.7 billion people worldwide remain offline, the majority of whom are living in the least developed countries where an average of just two out of every ten people are online as illustrated in Figure 6 (ITU, 2020).

Figure 6. Individuals using the internet per development status

Percentage of individuals using the Internet, by region and development status, 2019



1. ITU estimate
Source: ITU

Meaningful connectivity: Of those people who are connected and using the internet, many do not have meaningful connectivity (many countries still rely on 2G or 3G). Countries need new frontier technologies (like 5G and Wi-Fi 6) for high-speed broadband connectivity to reach digital equity.

Affordability and lack of digital skills: These factors remain some of the key barriers to the uptake and effective use of the internet, especially in the world's least developed countries. In 40 out of the 84 countries for which data are available, less than half the population has basic computer skills, such as the ability to copy a file or send an email with an attachment (ITU, 2020).

2.3 Supporting the digital transformation of education systems

As suggested in the previous chapter, to maximize the benefits of hybrid modalities and minimize their risks, it is necessary to attend to challenges and opportunities within education systems and the broader environment on a number of fronts. This section takes a look at some of the main areas for attention when it comes to the digital transformation of education systems.

As countries look ahead to this possibility, their experiences during the pandemic have made at least two points clear. The first is that, even in countries with relatively robust ICT and digital infrastructure, education systems are often ill-equipped to deploy hybrid learning because: (1) digital hardware and technologies are not integrated on a large scale into schools and everyday teaching practice; (2) teachers and students were caught unprepared and/or ill-equipped to embrace such learning modalities; and (3) the organizational and pedagogical synergies needed to implement it were not in place. As could be seen the world over during the early days of the pandemic, teachers in low-, middle- and high-income countries alike had to improvise virtual classrooms with basic and/or generic software or low-tech means, and students struggled to remain in touch with their schools.

Second, as the months rolled on, the pandemic demonstrated the need for governments and the international community to take a more deliberate, holistic and sustainable approach to the digital and educational ecosystems in which hybrid learning is situated. Gaps in funding and investment, along with weak capacities, risked rendering educators and learners unable to adapt to and benefit from hybrid learning, particularly learners living in low-income, marginalized and outlying areas.

Hybrid learning is bound to remain central to delivery as long as the COVID-19 pandemic continues, and potentially beyond the recovery phase as part of reimagined education. But most low- and middle-income countries will struggle to expand hybrid approaches as their public education systems are weakened by inadequate access to appropriate ICT devices, affordable data, digitally aligned curricula and e-learning materials, professional and personal development for teachers, and capacities for data collection, analysis and reporting. This is often coupled with an uneven power supply and scarce opportunities to practise digital skills outside the classroom. It is therefore essential to assess the extent to which education systems are ready for hybrid learning. Several diagnostic tools for this are described in Box 7.

Box 7. Diagnostic tools supporting assessments of education system 'readiness'

As well as rubrics and tools that assess countries' readiness for digital transformation, education systems could benefit from diagnostic tools that assess their readiness for hybrid learning to ensure that all of the pieces are in place.

World Bank SABER education diagnostic tools: The Systems Approach for Better Education Results (SABER) was launched by the World Bank in 2011 to help identify the policies and programmes most likely to create quality learning environments and improve student performance, especially among disadvantaged pupils. SABER produces comparative data, with the aim of helping countries strengthen their education systems and promote learning for all.

Guia Edutec: This is a multidimensional online tool that sets out to assess and monitor school-level readiness for the adoption of digital technology according to four key dimensions: vision, digital competencies, digital educational resources, and infrastructure. The Guia Edutec platform collects data from public schools on these dimensions and then classifies them according to their level of readiness in each dimension. Guia Edutec is based on the Connected School (CS) conceptual framework developed by the Centre of Innovation for Brazilian Education.

HEInnovate framework: Developed by the European Commission and OECD, this is a self-assessment tool to help higher education institutions explore their innovative potential. It guides them through a process of identification, prioritization and action planning in eight key areas. The tool also diagnoses strengths and weaknesses, opens up discussion and debate on the institution's entrepreneurial and innovative potential, and compares and contrasts its evolution over time.

2.3.1 Infrastructure development

A principal issue for education authorities lies in the explicit and implicit costs of the infrastructure and technologies needed to operationalize hybrid learning. The large-scale purchase of devices and the connectivity infrastructure could theoretically be financed through commercial or government models (see section 2.4). But the devices can prove to be a costly add-on if they are used sporadically by schools and learners, if the software expenditures are not considered, or if other costs such as for maintenance personnel, electricity, and content development, are omitted. At the same time, because a sustainable and comprehensive hybrid learning framework concerns the whole of government and many types of partners (outside of the telecom and tech sectors), it requires a cross-sector policy framework, participatory planning, and social dialogue.

Household access to digital technologies, ranging from mobile phones to advanced computers and tablets, is now common including in many low-income countries but tends to be affordable only to richer families. This means that access amongst lower income groups and disadvantaged learners is of great concern (see Box 8). Even if schools and communities have found work-arounds and managed to continue delivering schooling with low-tech solutions such as TV, radio, and even printed documents, it is crucial to develop connectivity and device programmes for low-income families.

2.3.2 Existing levels of digital integration

School closures due to the COVID-19 pandemic demonstrated that levels of digital integration into education systems are uneven; indeed, the previous use of digital technologies in schools was a key factor in the transition to effective remote learning (OECD, 2020).

In the future, the hybrid learning ecosystem will need to pay closer attention to SDG Indicator '4.a.1 Proportion of schools offering services, by type of service (Electricity - Internet - Computers)' (Tier 1) and more closely integrate learning objectives with national digital policies and educational goals, and build a shared understanding across sectors of the governance and organizational structures needed to support hybrid learning. The Republic of Estonia and United Kingdom (Wales) show promising practices in this area (see Box 8); their earlier investment in digitalization has facilitated the migration to remote learning during the crisis and is now supporting hybrid learning development.

Box 8. Spotlight on the Republic of Estonia and the United Kingdom (Wales)

In **Estonia**, the digital transformation of the education system began long before the coronavirus pandemic. Since the late 1990s, the government has made the development of digital skills, high-speed internet and a sophisticated IT infrastructure a national priority. Today Estonia is one of the most digitalized societies in the world, with a large number of public services available to citizens online and broadband internet coverage established across the majority of the country. The ambitious *Tiigrihüpe* (Tiger Leap) programme, launched in 1997, aimed to build up schools' technology infrastructure and had three pillars: (1) providing all schools with access to computers and the internet; (2) basic teacher training; and (3) native-language electronic courseware for general educational institutions. To accompany *Tiigrihüpe*, basic ICT courses for teachers were organized. In 1997, nearly 4,000 teachers participated in the 40-hour course, with thousands more in the following years. In 1999, new courses were introduced on electronic courseware, online information searching and the preparation of educational materials. By 2001, Estonia had already achieved its first round of stated digital education goals.

The country's digital and IT readiness meant that schools slipped seamlessly into hybrid forms of teaching and learning when the first lockdown occurred. Moreover, most Estonian schools were routinely using digital study materials including a platform of digital books called Opiq and electronic school management systems such as eKool, which connects pupils, parents and teachers. Students routinely have access to their own assigned iPads, which are centrally managed by schools and used to deliver lessons, and the children have occasional online study days when they work from home rather than in the school building, while their teachers are involved in other tasks.

In **Wales**, the Hwb EdTech programme has been in operation since 2012. It is the country's digital initiative providing broadband, digital infrastructure and now cloud services to all schools. Since its inception, the programme has supported Welsh schools and local authorities in upgrading their digital infrastructure, including the resources to support learners engaged in remote learning. More recent efforts have sought to ensure that all schools are working towards the Education Digital Standards. In 2019, the Welsh government announced that its local authorities were set to receive £50 million to upgrade educational technology equipment within schools. The money would guarantee that schools are better equipped to embrace the changes brought about by the new Curriculum for Wales. The Hwb platform has played a crucial role during the difficult period of the pandemic, offering access to a wide range of bilingual digital resources to support the delivery of the curriculum, along with provision for key areas such as online safety and well-being. The programme has provided over 128,000 devices since the start of the pandemic. A further investment of £15 million helped to secure Mi-Fi connectivity and software which has allowed schools and local authorities to provide the necessary technology to support digitally excluded learners remotely.

2.3.3 Assessing teachers' readiness for their new roles

Forms of blended and hybrid learning assume that teachers have technological, pedagogical, and content knowledge to operate relevant educational technologies. They also assume that teachers have developed a clear understanding of how to steer and shape pedagogy, content and technologies to suit different learners' needs and ensure reactivity when students are struggling. This is not always the case. Yet the transition to hybrid and more blended forms of learning over the long run will pivot, in large part, on the readiness of teachers for these digital roles.

Most certainly, the emergence of hybrid learning will change the nature of the educator's role and lead to new practices and skills that need to be incorporated into their everyday practice. They will need support and opportunities to reflect on their practice and evolve as systems and expectations also evolve. At a foundational level of knowledge acquisition and capacities to engage in hybrid teaching practice, specific basic ICT skills will need to be mastered by the teachers. But frameworks and indices will again be needed that help teachers to assess their skills, competencies and dispositions across different types of criteria and rubrics. There are several tools and frameworks for assessing teachers' readiness. At an international level, the UNESCO ICT Competency Framework for Teachers (ICT-CFT) is an important tool used by many countries. In the European Union context, SELFIE is an online tool developed by the European Commission to support teachers in assessing their ICT skills. Box 9 provides a brief description of both frameworks.

Box 9. Frameworks for supporting teachers' skills development

UNESCO ICT Competency Framework for Teachers (ICT CFT): This framework is the result of a partnership between UNESCO, Cisco, Intel, the International Society for Technology in Education (ISTE), and Microsoft. Its intention is to guide educational policy-makers and professional learning development providers in producing pre- and in-service teacher training on the use of ICTs. The motivation is that 'teachers who have competencies to use ICT in their professional practice will deliver quality education and ultimately be able to effectively guide the development of students' ICT competencies' (UNESCO, 2018b). The ICT CFT provides a comprehensive set of 18 competencies that teachers need in order to integrate ICT into their professional practice and facilitate students' achievement of curricular objectives. The competencies are organized according to the six aspects of teachers' professional practice, over three levels of their pedagogical use of ICT. Version 3 of the CFT was published in 2018. This updated version incorporates inclusive principles of non-discrimination, open and equitable information accessibility, and gender equality in the delivery of education supported by technology. The impact of frontier technologies such as AI, mobile technologies, the internet of things, and OERs is also investigated.

SELFIE self-reflection tool: This is an online tool developed by the European Commission's DigCompEdu to help primary and secondary teachers reflect on how they are using digital technologies in their professional practice. Teachers can use the tool to learn more about the digital skills they have and identify areas where they can develop further. SELFIE for Teachers' questions and statements relate to uses of technology in the following six areas: professional communication and collaboration; personal learning and development; finding and creating digital resources; teaching and learning practice; student assessment; and facilitating students' digital competences. On completing the statements, the teacher automatically receives a report on their proficiency level in each of the areas with suggested next steps. Based on their results, teachers can design their learning pathways to further develop their digital competence and confidence. The data provided by the tool are always anonymous.

2.3.4 Teacher support and training

To equip teachers with the competencies and skills needed to fulfil the diverse roles in a hybrid environment, governments must commit to and invest in robust training programmes. Training should be incorporated into pre-service teacher preparation, and some countries have already started doing this. The training will require a dedicated plan for in-service development.

During the COVID-19 crisis and as part of the Global Education Coalition, UNESCO launched a Global Teacher Campus to train one million teachers on remote learning and pedagogies.

In Latin America, online courses for teachers have largely focused on building and improving digital skills in the context of distance education. For example, in Brazil, the *Educação em Rede* (Online Education) is a teacher-training platform that has aimed to train over two million teachers in digital and pedagogical skills during the pandemic. To date, 500,000 teachers have enrolled in rapid courses. The Plurinational State of Bolivia has provided a course entitled Training for Digital Teachers (*Dirección Departamental de Educación La Paz*, 2020), while Ecuador launched a self-learning course for teachers called My Online Classroom (Ministry of Education of Ecuador, 2020). In El Salvador, a cascade training process has been initiated to train 100 technical specialists from the Ministry of Education to provide assistance for capacity building in online education; in turn, these specialists are expected to train the 46,000 teachers in the public education system (Ministry of Education of El Salvador, 2020a). Other countries have also focused their teacher-training responses on health-care issues. In Mexico, thanks to a public-private partnership strategy with national and international organizations (including technology companies, non-profit organizations, and universities), the Secretariat of Public Education gathered educational resources and provided training on digital and remote learning skills, reaching over one million teachers (Ripani and Zucchetti, 2020).

Box 10. Spotlight on Uruguay

As part of the Ceibal at Home programme, the Ministry of Education designed an immersive, 360-degree training experience for teachers using the same resources and story-telling techniques as those intended to be adopted in their lesson plans. Teacher training was provided through low-tech platforms suitable to be adapted to low connectivity contexts, such as analogue TV, as well as digital channels, including the Ceibal Plan LMS and social media. For example, there were podcasts delivered on

Spotify suitable to be broadcast by radio. Ceibal also experimented with a TV magazine featuring teacher-training content, including strategies for remote and blended learning. Some of the suggested materials included over 1,500 OERs and promoted the use of tools that are commonly available among students, including instant messaging and social networks. A national survey suggested that Ceibal's educational resources were those most used by teachers in Uruguay, and according to a ranking by Alexa, its LMS was the fifth-most-visited website in the country by mid-2020.

2.3.5 Updating curricula and contents

For those unfamiliar with the creation, curation, and storage of quality digital materials, simply digitalizing printed content into PDFs and uploading it to the internet has been a common practice since the emergence of COVID-19. However, rich digital content involves much more than mere conversion.

In tandem with the foundational infrastructure and connectivity needed for hybrid learning, the challenge is to digitalize educational content and adapt curricula for digital formats and platforms, paying close attention to pedagogical and quality considerations so that teaching and learning objectives and standards are not compromised.

Digital content: This is already replacing traditional textbooks and materials in many countries, and includes online courses (like the Massive Open Online Courses, MOOCS), digital textbooks, images, videos, student assessments, library licensed materials, self-developed materials, or a combination of these. There are three main types of digital content (shown in Table 4 in section 2.4.4), with access and design influenced by their costs, among other pedagogical concerns (US Department of Education, 2017b).

Curriculum alignment: In general terms, digital materials are more relevant and more robust when they are aligned with the national or government curriculum. In this process, certain curricular decisions related to digitalization will have cost implications. For example, digitalizing content for specific subjects or grades will take less effort and budget than digitalizing the entire national curriculum. It also appears less costly to align and adapt content from a non-digital to a new hybrid learning curriculum than to develop digital content for two separate curricula (GEF, 2021b). Finally, many educational materials will need to be translated into local or indigenous languages. The processes of alignment and adaptation and associated costs should therefore be factored into the hybrid learning investment plan.

OER platforms: In low-resource environments, access to digital content and learning support materials will need to be easily accessible and preferably cost-free, particularly for disadvantaged or displaced learners. Where possible, devices should be preloaded with appropriately adapted hybrid learning materials to last at least one school year (UNESCO, 2021a).

OERs and Open Courseware (OCW) can be drawn upon to support different types of hybrid learning. OERs are 'teaching and learning resources that permit no-cost access, use, reuse and repurposing by others, with no or limited restrictions' (McGreal, Miao, and Mishra, 2016, p. 1). Even print copies can be included in this. Teachers may therefore choose from an array of content and tools that have been designed and configured specifically with hybrid and blended learning in mind, including help in building lesson plans and courses.

Many digital repositories housing OER and OCW (as well as MOOCs) now provide a useful means of storing, managing, reusing and curating digital materials for the purposes of education, research and administration. They can be subject-focused or institutionally focused, stand-alone, networked or federated (see Box 11).

Box 11. Spotlight on Kolibri

Developed by Learning Equality, Kolibri is an adaptable end-to-end suite of open tools, openly licensed learning resources, and do-it-yourself support materials, designed for teaching and learning with technology in environments where there is little to no internet connectivity, particularly during the COVID-19 pandemic. At the centre of this ecosystem is an open-source learning platform that provides robust functionality to support the kinds of personalized and differentiated learning that are typically only available in online learning environments.

The wealth of open resources from its library, along with locally developed materials, can be aligned to a national curriculum using the Kolibri Studio curricular tool, and educators within the learning platform can create lessons and quizzes with these resources. From there, Kolibri enables educators to facilitate remote learning by capturing learning analytics, and allowing teachers to track learner progress and get notifications for when additional support for individual learners is needed — all without requiring access to the internet.

On a last note, as with any form of digital content or online interaction, there are potential dangers relating to personal security and safety and the risk of compromising personal information. This may be a particular issue for vulnerable groups and those previously unaccustomed to online learning and the ways in which unscrupulous actors may hack, introduce malicious software, exploit phishing strategies, infiltrate data and devices, and so forth. There are also issues regarding the use of digital trace data in education. Whilst such data is considered by some to be essential to educational quality, improvement and efficiency, others highlight ethical issues arising from its use, especially as the amount of data shared between a growing number of actors in the educational marketplace increases.

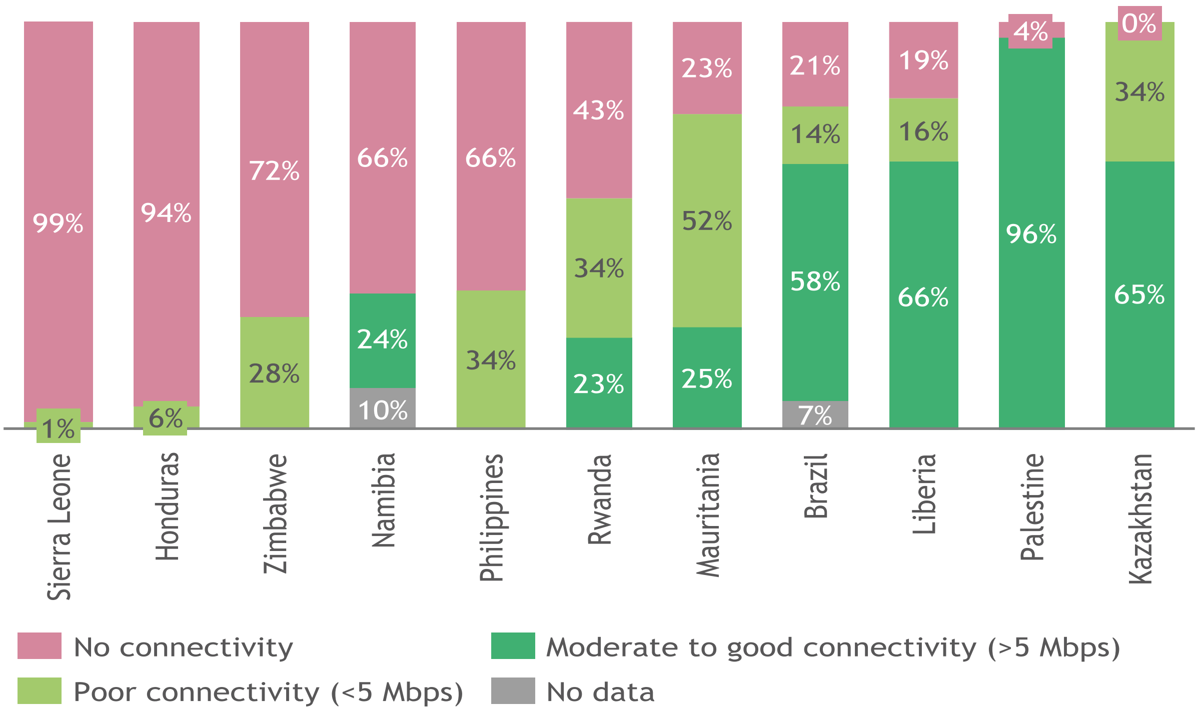
In all cases, it is essential to obtain consent from students and their guardians with respect to data collection and usage, and to renew this consent whenever new tools are employed or data usage changes. The safety of learners and the integrity and privacy of student data should be prioritized at all times. A more detailed discussion of student safety online is contained within the report The Digital Transformation of Education: Connecting Schools, Empowering Learners.

2.3.6 School-level readiness (infrastructure and connectivity)

Telecommunications infrastructure and connectivity at school level are necessary and crucial conditions for school- or home-based learning under hybrid models. It is clear that for low-resource contexts, key considerations include the unaffordability of internet connections and the lack of computing devices like desktops, laptops, tablets and smartphones. Other devices like projectors, smart boards and smart TVs (and even printers) will also be needed for classroom-based hybrid learning and lab models.

Connecting schools requires resolving a number of specific technical issues, as illustrated with examples drawn from six developing countries which differ markedly in terms of service provider landscape, regulatory framework, geography and socio-economic context. These six countries, Brazil, Honduras, Indonesia, Nigeria, Rwanda and Sierra Leone, are in different stages of development when it comes to school connectivity (see Figure 7).

Figure 7. Status of school connectivity in six focus countries



Source: Giga, Project Connect.

At the same time, when rolling out connectivity to schools, minimum targets for meaningful connectivity should ideally be set (see Box 12). This is for a number of reasons. First, it helps to ensure that schools do not end up with weak connection levels that are insufficient to run online classrooms. Second, minimum targets help to ensure that core functionalities (within ed-tech programmes and platforms) can be conducted. Third, targets help with the costing of connectivity in different regions and allow for more transparency, clarity, and realistic budgeting. To ensure a minimum bandwidth for schools that is meaningful, the UNSG's Digital Cooperation Roadmap can be used.

Box 12. The Giga initiative

Launched by UNICEF and the ITU in 2019, Giga has set a target for meaningful internet connectivity for schools for the year 2024. Given the ever-evolving demand for faster connections, a view on years thereafter has not yet been provided. Giga is targeting a 20 Mbps download speed per school, with a fallback to 10 Mbps if needed. Achievement of this minimum speed of 10 Mbps allows students to open documents, take online assessments, receive feedback, ask questions, and watch online videos. A 20 Mbps connection enables students to do all of this and also watch several video-streams per school and use cloud-based apps. Ideally, a hybrid learning model would be deployed and the school would have access to speeds above 20 Mbps with students having at least 2 Mbps of internet connectivity at home. However, for many developing countries this may be challenging to finance in the short term. It is therefore seen as a subsequent target to work towards. Stimulating community demand using the school as a hub will aid in rolling out connectivity sustainably.

Given the minimum of 10 Mbps per school, certain technologies are out of scope. For example, 2G and 3G will be insufficient for students to receive a meaningful connection. Technologies that meet the minimum requirements include 4G/FWA,[6] 5G, satellite, local WISP-operated networks, and fibre.

6 For readability we will refer only to 4G; however, FWA can be equally considered.

Finally, as is the case with all technological and educational innovations, any discussion around the 'hard' elements of school-level readiness for hybrid learning must be accompanied by consideration of, and investment in, the 'soft' elements. In other words, for hybrid learning to bear fruit, serious analyses of pedagogical delivery and engagement are needed.

2.3.7 School leadership

The role of school leaders in planning, adopting, rolling out, and supporting hybrid learning cannot be understated. School leaders are the primary interface with teachers when considering which models of hybrid learning may be most appropriate for students and the school context. They are responsible for ensuring compliance and alignment with the national curriculum and priorities regarding hybrid education, and the accreditation and credentialling frameworks that govern hybrid learning in their location.

A further critical role of leadership is to generate buy-in from school staff so that teachers are enthusiastic, motivated, and prepared to engage in their teaching practice through hybrid learning modalities. They should communicate the value of hybrid approaches and promote teachers' confidence and agency in transitioning to new modes of teaching and learning (see Box 13). Finally, school leaders will most likely serve as a key liaison with families and the wider community throughout the transition to hybrid approaches.

Box 13. Spotlight on Portugal: Escola Digital (Digital School)

A strong example of school leadership is seen in the *Escola Digital* (Digital School) initiative in Portugal. In the framework of this programme, the figure of the *Digital Ambassador* was created with the objective of streamlining the implementation of local digital transition plans.

The Digital Ambassadors develop articulated work between the Directorate General of Education, the School Association Training Centres, and the schools connected with those training centres. The role of school leadership is very important in disrupting old practices and defining the strategies of each school. School leaders, who may also serve as budget holders, are responsible for securing the resources essential to hybrid learning, and for ensuring the sustainability of these resources. This is especially important as hardware often requires replacing, and software requires upgrading.

2.3.8 Learner and household readiness

The ramifications of the COVID-19 pandemic have highlighted the importance of the links between home and school. With the resources at their disposal, school leaders and teachers have sought to mediate differences in families' economic, cultural and social capital through different types of engagement. But empowering learners with confidence in digital skills, advancing the adoption of technology among learners and their families, and meeting the need for ongoing socio-emotional support have received less attention. All of these elements will be critical in fully activating both synchronous and asynchronous hybrid approaches and generating positive learning outcomes over the long term.

Hybrid learning developments thus need to reconsider home-school relationships and how teachers and schools might engage effectively with families, key carers and support services to bolster children's learning (especially younger children, at-risk groups, and those with special educational needs). Where technological approaches are out of reach or inappropriate for the context, learning can be imparted through low-tech approaches that are more suited to the circumstances. Brazil and Mexico are promising examples of countries investing in learners and household readiness (see Box 14).

Box 14. Spotlight on Brazil and Mexico

The E-Digital Strategy in Brazil shows how one country is attempting to improve digitalization in education by strengthening the skills needed for the uptake of digital services. Programmes to promote digital competencies have been introduced in the high school curriculum and teachers are encouraged to disseminate digital content. The federal government has also promoted the use of online learning resources for household IT skills through its Brazil+Digital programme, which serves as a hub for free online courses.

In Mexico, the RECREA JALISCO platform developed by the Federal Ministry of Education and State Government of Jalisco in partnership with Thincrs and Udemy aims to improve the digital skills of the state's high school and undergraduate students and teachers. To do this, the project works on four levels: (1) diagnose the competencies of public school teachers and students in digital skills using the DigComp framework; (2) design and personalize learning paths for training teachers and students; (3) certify teachers and students who reach the required levels of the DigComp framework; and (4) create digital education ecosystems. It was launched in late 2019 and is still running as of 2021.

An initial evaluation is performed through an adaptation of the EU's DigComp framework that enables the design of personalized learning paths for each beneficiary. The incorporation of personalized learning paths with diverse opportunities for evaluation further allows the engagement of users with their digital abilities, since they can monitor their progress according to their interaction with the platform. So far, the initiative has supported the skills development of 4,100 teachers and thousands of students located in 12 geographic zones in Jalisco. Some 2,346 teachers have levelled up their competencies from basic or mid-level to more advanced levels. Current results show that 24.84 per cent of the users have accomplished outstanding levels on several competencies of the DigComp framework, and 17.46 per cent reached the specialized level.

Learning content platforms can also provide a means through which parents might develop the digital skills they need to support, and possibly learn with, their children. To ensure equity when selecting an appropriate hybrid learning method, administrators and teachers should have detailed knowledge of the resources their students can effectively use at home. This will mediate the extent to which learners can participate, and this information will help identify the most appropriate and inclusive approach.

2.3.9 System-level interventions and systems strengthening

Setting up effective and resilient hybrid-learning systems that combine both remote and in-person learning requires attention to many of the challenges of remote learning (student adoption, engagement, and equity) alongside new challenges related to equitably allocating scarce teaching and infrastructure capacity, and managing the operational complexity of the switch from remote to in-person models (McKinsey and UNESCO, 2020). What's more, in the era of COVID-19, the threat of resurgence requires education systems to be ready to switch between these models at any time to ensure learning continuity.

Therefore, developing resilient hybrid-learning models requires an iterative approach. This begins with system leaders and school leaders **setting the parameters of countries' hybrid-learning strategies and mobilizing partners to align their expertise and resources around its guiding principles**. As systems transition out into a 'recovery' period, policy-makers, practitioners and stakeholders alike are also waking up to the need to ensure that standards are upheld in terms of pedagogical approaches and the quality of teaching, learning and other instructional resources organized and curated within online and OER repositories.

New legislation may be needed to empower schools and institutions to make more localized decisions around the use of digitalized online content to support the curriculum. Such legislation needs to be harmonized with existing laws and regulations around telecoms and digital infrastructure, and promote an enabling regulatory framework to ensure that educational digitalization is sustainable. All of these efforts will ensure that after the immediate COVID-19-related problems are tackled, school systems can move forward on a strong legal basis without being obliged to go back to dated analogue modes. Some provinces in Canada have adopted such legislation and set up new institutional frameworks (see Box 15).

Box 15. Spotlight on Canada (Ontario and Manitoba)

In the 1920s, students in Ontario began learning through the mail and radio, and then, as technology progressed, combinations of video conferencing and online learning were added. This remote learning has been publicly governed by school boards and the provincial government, and is about to undergo a radical change. It is the firm belief of Ontario's school boards that e-learning courses delivered through local schools, or collaboratively across school districts, where teachers know their students' learning needs, is a far superior model of delivery (The Ontario Public School Board Association, December 2020).

With this in mind, the province introduced Policy/Programme Memorandum No. 164: Requirements for Remote Learning during spring 2021 to make remote learning a permanent part of Ontario's education system, and to change the way it is governed. Among other things, the legislation will:

- Require school boards to permanently offer synchronous, remote learning in elementary and secondary schools for any student whose parents who would prefer this option for their children.

- Require boards to offer synchronous online learning when schools are closed for emergencies or snow days.
- Create new regulatory authorities to:
    - Dictate rules governing the roles and responsibilities of school boards, school authorities, and other entities in the delivery and coordination of online and remote learning.
    - Make decisions on things like the software, information systems and technology-based instructional tools and resources that will be used to support online learning and data-sharing processes.
    - Establish data-sharing processes that enable an effective online learning system.

The new legislation sets the stage for the Ministry to make regulatory changes under the Ontario College of Teachers Act, allowing the College to make it mandatory that initial teacher education programmes cover instructional pedagogy in an online environment. It also institutionalizes the shift in control over online courses from school boards to the school level. Under the new system, school boards will still have some input into the kinds of courses that are offered online, but TVO/TFO will be responsible for developing the content for online courses and maintaining the course catalogue that students will access centrally.

The Manitoba Remote Learning Support Centre and InformNet (an online teacher-directed learning option for grades 9 to 12) aim to ensure continuity of learning, build capacity, achieve greater consistency, and support educators in providing effective online learning. The plan includes:

- the development of a remote learning framework to outline guiding principles to help build common understandings and support evidence-based practices for hybrid learning and teaching;
- the development of remote learning standards to ensure consistent application of programming across Manitoba during the pandemic; and
- the launch of a remote learning support centre and expansion of InformNet to underpin system-wide remote learning from kindergarten to grade 8, including for students and families who have registered for homeschooling in response to COVID-19.

This enables an improved distance-learning experience for students throughout Manitoba. In addition, in order to benefit students with little to no internet connectivity, funding for the teacher-mediated option is being piloted for grades 5 to 8 and expanded to grades 9 to 12 (see the Government of Manitoba website).

A second critical component is to **assess the system's (and schools') current state and readiness**, including the potential costs and effectiveness of all remote-learning options, school capacities (e.g. budget, infrastructure, appliances, staff availability, and physical space) and teachers' capacities for providing hybrid learning according to students' and families' needs and preferences. These dimensions may lean on the 'readiness' indices and rubrics mentioned earlier in this chapter. On a practical and operational level, building strong databases with student/family contact details has helped certain countries to support readiness where schools have suddenly needed to go back into lockdown. Such data facilitates learner and family liaison, materials delivery, and an early warning system to keep track of vulnerable students (see Box 16).

Box 16. Spotlight on Nigeria: EdoBEST

Since 2018, the EdoBEST programme, with the support of its more than 11,000 teachers across 900 schools, has been building a database with the profile and contact information of every student. With this information, teachers were able to contact parents as soon as the government announced school building closures. It has also helped them to inform parents of developments, maintain personal contact, deliver learning materials, and provide remote support to ensure that children continued learning. Automated assessments are also part of EdoBEST's efforts to foster effective use of digital technologies and learning during the pandemic. Students can access interactive quizzes through their mobile phones on a daily basis. Quizzes are effective for helping students to practise a wide range of skills from using vocabulary to solving equations, retain what they learned, and receive instant automated feedback through WhatsApp or text messages. All quizzes are aligned to the Edo state curriculum and the education level.

A third component is for systems (and schools) to **monitor and adjust**. Hybrid-learning models are experimental by nature, and systems at all levels need to evaluate and adjust their approaches over time as circumstances evolve (see Figure 8). High level decision-makers will need to know how systems are doing overall (to understand what is working) and assess the extent of learning gains and/or losses. Indeed, learning assessments and a solid monitoring and evaluation plan are just as essential for hybrid learning environments as they are for traditional ones.

According to data collected by the Regional Bureau for Education in Latin America and the Caribbean (OREALC/UNESCO Santiago), in April 2020, several Latin American countries started to make decisions regarding the administration of large-scale assessments. Mexico introduced an alternative assessment that takes into account the fact that major tests, including the learning portfolio assessment, will not be administered and there will be no end-of-year examinations for the 2020-2021 school year. Ecuador, meanwhile, is postponing some certification tests for education professionals and is considering alternative methods for national assessments.

The basic tenets for Measurement and Evaluation (M&E) in in-person teaching and hybrid learning remain the same, however (see Box 17): determining the objectives, deciding what data to collect and how, and selecting appropriate measurement tools and approaches (USAID, 2021).

Box 17. Spotlight on Pakistan: Partnerships to support the M&E of blended learning

Pakistan has attempted to create an M&E system for blended learning which could be adapted for monitoring hybrid learning. In late 2020, the EdTech Hub worked for two months with the country's Ministry of Federal Education and Professional Training (MoFEPT) to develop an M&E framework for a pilot of a blended learning programme in Islamabad. The partnership between technical experts and the Ministry resulted in a robust framework covering a comprehensive set of indicators, and laid the foundation for its implementation (Khalayleh et al., 2021). The M&E framework is contextualized to Pakistan, to ensure buy-in and local ownership among stakeholders and to guarantee local capacity to assess the impact and further refine the framework as needed.

The framework is holistic and encompasses 17 separate indicators spread across the following components: infrastructure and access; learning materials; teacher training; instructional practices; improved quality of learning; a teacher support network; and parental engagement.

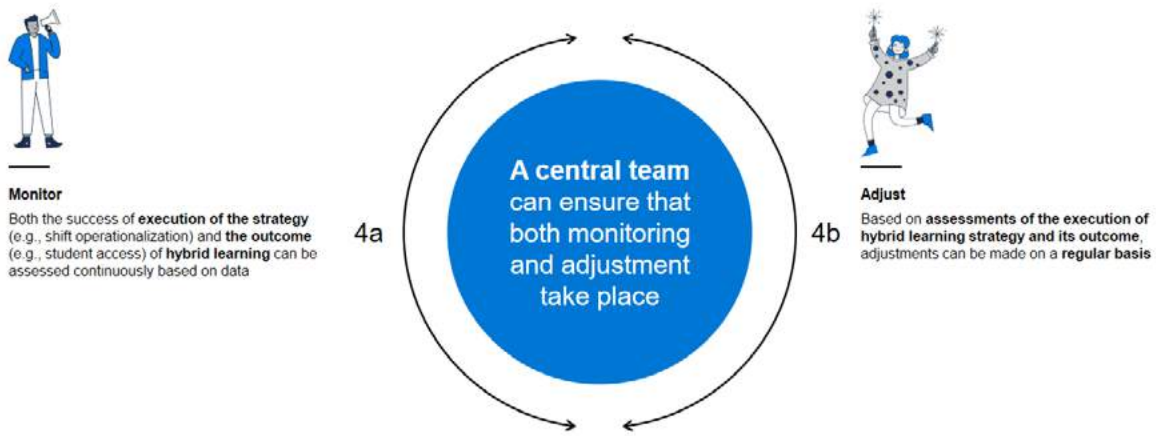
The initial framework has been finalized and the MoFEPT is responsible for its operationalization and implementation. This experience revealed that:

- Designing an M&E framework for blended learning must be aligned to the specific context in which it is used and responsive to the goals of the particular initiative or programme; and
- Designing and implementing the framework is an iterative process, and the framework should be continuously refined and improved upon based on the data and feedback collected.

This model of collaboration, its process, and the resulting framework are intended as a global public good and can serve as an example for other countries preparing to undertake similar M&E planning.

At school level, measures are needed for school leaders and teachers to understand whether classroom-based and more personalized approaches are working in terms of student engagement and learning outcomes, and regularly integrate feedback from students, parents, and peers into their practice.

Figure 8. Monitoring and adjustment at the heart of hybrid learning (McKinsey and UNESCO, 2020)



Looking ahead, just as hybrid approaches to teaching have been adopted in the context of COVID-19, hybrid forms may also be needed for assessments, data and evidence gathering, and M&E processes in order to overcome challenges. Certain educational technologies already embed ongoing learner assessments through the employment of AI. Multimodal approaches using phone calls, SMS, mobile devices and software can empower teachers to create surveys and collect, manage and upload data to assess engagement and react in real time.

2.4 Self-sustaining funding for hybrid learning

Telecommunications infrastructure and connectivity are necessary and crucial conditions for hybrid learning. Currently many countries have insufficient digital infrastructure and/or financial resources for deployment. Additionally, as is the case with all technological and educational innovations, the 'hard' elements of hybrid learning need to be accompanied by investment in the 'soft' elements.

In response to COVID-19, many governments hurried to invest in remote and digital learning solutions to provide immediate support and relief to learners and their families. Funds were assigned or earmarked to upgrade ICT infrastructure, purchase digital devices, develop distance-learning platforms, and create new tools or enhanced integrated solutions (including digital curriculum development). These responses were possible mainly because governments undertook large-scale fiscal and monetary measures or relied on international financial support, particularly low-income countries (UNESCO, 2020c). Comparatively, in other countries, funding was available through contributions from other ministries (e.g. infrastructure, ICT and energy) or savings from other budget lines (see the Compendium).

The challenge remains that investments are required when competition for government funds is rising (UNESCO-UIS et al., 2021). This has been highlighted by the Broadband Commission (BBC) for Sustainable Development, the Global Education Forum (GEF), the ITU, UNESCO, UNICEF and the United Nations Secretary-General, all of whom have argued for a holistic, comprehensive and equitable approach that enables the overall sustainability of hybrid learning investments.[7]

While education budgets increased from 2019 to 2020 in 49 per cent of countries for which data are available, the mobilization of additional government funding is constrained by limited revenues. The pandemic resulted in severe income shocks across all countries, and bilateral aid to education is expected to decline. The pandemic has also negatively impacted the capacity of households to afford school expenses, such as tuition fees for private schools and other costs of attending public school (UNESCO and World Bank, 2021). As requested in the 2020 Global Education Meeting Declaration, budgets will need to be bolstered further to compensate for learning losses, the disruption of education systems and the reduction in access to schools.

From an economic perspective, investing in hybrid learning could enhance recovery prospects, and in fact may help to reduce long-term financing needs (UNESCO, 2020a). Beyond the short-term investment challenges presented by COVID-19, the financing opportunities created by the digital economy and frontier technologies are plentiful. Recent estimates for Europe indicate that 5G will have a direct impact through output (sales) between 2021 and 2025 and an indirect impact through the value chain of every economic sector. It is anticipated that 5G will generate an estimated €1 trillion for the region's GDP (Accenture, 2021). In summary, viewing investments in hybrid learning solely as an education response and recovery option is a short-sighted policy. Frontier technologies will drive future economic resilience, and investments in hybrid learning will be part of that.

This section explores the practicalities around the call for holistic, comprehensive and self-sustaining financing of hybrid learning. It also goes a step further to present hybrid learning financing frameworks and policies from a sector-wide development perspective, in which the cost model considers all significant elements or enablers/building blocks of the hybrid learning ecosystem. The costing model offers governments a tool for exploring, analysing, engaging with and agreeing upon appropriate hybrid learning policy decisions and translating them into the pedagogical organization and subsequent resource allocation.

2.4.1 Financing framework: Policies and financing options for hybrid learning

Hybrid learning is simultaneously a strategic goal and a means to achieve significant and overarching sustainable development and educational goals. Therefore, investment in hybrid learning requires consideration for inter-sectoral and whole-of-government strategies in relation to achieving digital transformation and mission-critical educational goals, including issues, constraints, needs and strategic targets for the broader education system (Chang, 2006).

The **Nigeria** example illustrates how hybrid/digital education is situated within the wider digital economy and broadband plans (see Box 18). The Nigerian case also shows the complexity of these policies and the challenges that countries are facing.

7 See, for example, BBC (2020b, 2020c); GEF (2021a); ITU (2020a, 2021); UNESCO (2020b); UNICEF (2020); and United Nations Secretary-General, UNESCO, and UNICEF (2021).

Box 18. Spotlight on inclusive recovery and digital growth in Nigeria

With more than 200 million residents and a GDP of $429.4 billion, Nigeria is the most populous country and the largest economy in Africa. In 2018, Nigeria's key growth drivers were the services industry and ICTs, with digital technologies expected to be a major driver in the future. To reposition and diversify the Nigerian economy away from dependence on the oil and gas sector, two policy frameworks were developed to guide the digital-led growth strategy: the National Digital Economy Policy and Strategy for a Digital Nigeria (2020-2030), launched in November 2019; and the Nigeria National Broadband Plan (2020-2025), launched in March 2020 by the Federal Ministry of Communications and Digital Economy (FMoCD).

The FMoCD is based on eight pillars: (1) developmental regulation; (2) digital literacy and skills; (3) solid infrastructure; (4) service infrastructure; (5) digital services development and promotion; (6) soft infrastructure; (7) digital society and emerging technologies; and (8) indigenous content development and adoption. These pillars align well with the Federal Government's Economic Recovery and Growth Plan (ERGP), which envisions inclusive economic growth for accelerated national development. The pillars further recognize that the journey towards digital transformation goes way beyond creating and applying digital infrastructure.

Investing in education and digital skills training opportunities throughout life is essential for equipping citizens with the skills necessary to thrive in a digital society. It is also crucial for improving employment prospects, stimulating the social innovations needed to achieve food and energy security, and ensuring the capacities and innovations required to continuously update the digital infrastructure that will transform Nigeria into a globally competitive economy. In Nigeria's context, the transformation of the education sector is therefore viewed as a critical enabler of the ERGP.

There are many challenges to overcome once digitalization of the education system is complete; however, nationally, 40 per cent of Nigerians (83 million people) live below the poverty line, while 25 per cent (53 million) are vulnerable. Prior to COVID-19, there was a noticeable digital divide in Nigeria, not just amongst learners but in the general population, including significant connectivity gaps outside of major urban centres and a sizeable gender gap. In 2017, Nigeria ranked 143rd out of 176 countries scored by the ITU's ICT Development Index, making it one of the lowest-ranking countries that is not a least developed country (LDC).

Across Nigeria, only 42 per cent of the population used the internet in 2018 (ITU, 2020b) and around 42 per cent of learners lacked access to home computers or the internet. An estimated three million learners live in places not served by mobile networks. Moreover, around 60 per cent of the female population is unable to access the internet, with research showing that deeply entrenched social, gender, and cultural norms present a significant barrier to women and girls accessing and using technology.

Meanwhile, the adoption and integration of technology into the Nigerian education system is still very minimal. From early childhood to secondary level, educational technologies tend to be more available in private schools. The public system is disadvantaged by inadequate access to ICT devices, digitally-aligned curricula, e-learning materials, professional and personal development for teachers, and data collection, analysis and reporting capacities. These disadvantages are coupled with an unreliable power supply and scarce opportunities to practise digital skills outside the classroom.

Within higher education, the infrastructure and digital resources available for online, open, web-based, computer-mediated and blended teaching are also patchy. Prior to COVID-19, most departments across universities in Nigeria did not have networked computers. There were few course videos, digital learning modules and downloadable resources for students – everything was paper-based and analogue.

The National Policy on ICT in Education (2019) provides guidance on the expectations of all stakeholders in the entire process of digital or ICT integration. The policy is intended to empower teachers through ongoing comprehensive professional development. All teachers and trainers acquire the knowledge and skills to integrate technology into a challenging and interdisciplinary curriculum, addressing learners' specific needs, developmental levels, and learning styles. The National Education Research and Development Council has partnered with stakeholders to launch an innovative e-curriculum. In 2020, the government also launched the Digital Nigeria eLearning Platform in cooperation with the African Development Bank and Microsoft to equip youth with marketable digital skills.

Achieving Nigeria's digital transformation goals will require multi-stakeholder collaboration and public-private partnerships, with the government initiating the policy and regulatory frameworks and incentives needed to drive progress. The pandemic has already led to changes in the education sector in Nigeria, including innovative delivery and financing partnerships between state governments, technology companies, financial institutions and telecommunications operators, which were deployed to support the continuation of learning. Partners in the ed-tech sector took opportunities to roll out new learning platforms and scale up existing remote learning modules. The COVID-19 Task Team, based in the Federal Ministry of Education, currently strategizes, supports and monitors interventions to ensure curriculum relevance and guarantee that private sector participation meets expected standards.

Sources: African Development Bank (2020); *African Leadership* (2020); Equal Access International (2021); ITU (2020b); World Bank (2019).

2.4.2 Principles for investing in hybrid learning

Any hybrid learning financing framework should be based on the following **principles**:

Learners and educators at the centre: The hybrid learning transformation starts with putting educators and learners at the centre of the investment, encompassing dedicated delivery, pedagogy and engagement strategies. Chapter 1 showed the way decision-makers structure the education system to allow for the hybrid learning transformation and which models they adopt and implement. These are essential aspects that depend on countries' broader economic situations and resources.

Equity and inclusion: These are cornerstones of SDG 4 and the Education 2030 Agenda, and should remain as such in any hybrid learning policy or investment framework. Although the agenda does not explicitly reference hybrid learning, the COVID-19 context exhibited that the availability of, and access to, hybrid learning is a tangible manifestation of the digital divide, and associated discrimination and inequality. No hybrid learning educational vision or goal is met unless it is achieved for all.

Governments should attempt to guarantee that the conditions for accessing and enjoying hybrid learning are equally distributed amongst learner groups with different vulnerabilities and experiences of marginalization, discrimination and exclusion. A focus on equity in the distribution of resources entails eliminating or reducing the economic obstacles that limit the accessibility and affordability of hybrid learning.

A hybrid learning financing plan which relies on households' contributions for the devices or data connectivity, for example, goes against a state's obligations and the learner's right to education. Such obstacles are particularly significant in developing countries, where broadband services are less affordable than in developed countries due to the relative costs of capital for installing networks.[8] UNESCO's 2022-2025 draft strategy on technological innovation in education calls for careful consideration of low-cost solutions when framing hybrid learning investments (UNESCO, 2021e). Moreover, the draft Global Declaration on Connectivity, supported by the international community, materializes this principle (see Box 19).[9]

8 The BBC defines internet affordability as '1 for 2' — one GB of mobile broadband should cost no more than two per cent of the average household income (A4AI, 2020a). Broadband prices have declined since 2015 from seven to three per cent of average monthly income; yet broadband continues to be less affordable in low-income countries, in part due to the relative costs of capital for installing broadband networks. The acceleration of the transition to digital since COVID-19 emerged has encouraged discussions of the measures of internet affordability and the price targets. In collaboration with the ITU, the Alliance for Affordable Internet (A4AI) proposes a revision of the '1 to 2' definition to one that considers the 'journey from 1 to 5', where the cost of 5GB of broadband remains at two per cent of average monthly income by 2026 (Woodhouse, 2021).

9 Reduced internet access costs are also supported by the Broadband Commission and the ITU's global frameworks. On the one hand, target 2 of the BBC's *2025 Targets: Connecting the Other Half* (launched in 2018) pronounces the need for entry-level broadband services to be made affordable in developing countries, at two per cent of monthly gross national income per capita (BBC, 2021). On the other hand, targets 1.3 and 2.6 of the ITU's *Connect 2030 Agenda for Global Telecommunications/ICT Development* (also adopted in 2018) state that by 2023, access should be 25 per cent more affordable and broadband services should cost no more than three per cent of the average monthly income in developing countries (ITU, 2018a, 2018b).

Box 19. The Global Declaration on Connectivity for Education reinforces the principles of free and equitable connectivity

The international community is engaged in removing connectivity barriers for education. A Global Declaration on Connectivity augurs a new direction for integrating connected technology in education in a sustainable financing approach.

The draft Declaration includes the following principles and commitments:

1. Centre on the most marginalized: Policies and investments must be recalibrated to focus on learners most in need (refugees, students with disabilities, girls and women, teachers in remote areas and other underprivileged learners and educators). Connectivity should reach all learners everywhere; it is no longer a luxury, but an essential means for making the right to education a reality. The Declaration calls for ensuring sustainable financing of universal connectivity and opposing approaches that see connectivity as a one-time expenditure. Affordable connectivity also implies that governments should consider the free or subsidized rates that mobile service operators can offer under education plans. Sustainable investments have to supplement and enrich in-person formal education, not replace it or slow down the accumulated progress toward financing public schooling.

2. Expand investment in free and high-quality digital education content: Emphasizing the need for free and affordable internet connectivity does not mean that investments end there. Open and free public digital learning platforms should be established, continuously improved, and made accessible to a range of audiences and devices.

3. Pedagogical transformation is essential for digital education: Governments should avoid replicating traditional schooling models in the digital space and use technology to strengthen, not diminish, other dimensions of learning (e.g. social, civic). Data should be protected, and internet use safeguarded.

Source: UNESCO (2021c).

Focus on meaningful connectivity: The concept of *meaningful connectivity* suggests that 'non-technology and non-economic issues play a central role in decisions to participate online or not' (Broadband Commission, 2019). This entails focusing not only on infrastructure but also on thoughtful approaches that meet the needs and expectations of current and potential users. Meaningful connectivity also requires the hybrid learning investment framework to address the local ecosystem whilst promoting whole-government approaches and innovative partnerships. As per the aspiration of the SDG 4/Education 2030 Agenda: education policy and action plans should be integrated into sector-wide, multi-sectoral and broader socio-economic development and sustainable planning.

Integrate hybrid learning objectives with national and international education goals: Under SDG 4 and the Education 2030 Agenda, states commit to providing free (and compulsory) primary and secondary education. Therefore, a state's obligations extend to guaranteeing education, including hybrid learning technology, that is free of costs for the learners. To be holistic, comprehensive, and sustainable, the hybrid learning investment should be framed within the context of the international education development goals. The 2030 Agenda views ICT as a key support pillar for accelerating progress towards the SDG 4 targets. Hence, any hybrid learning investment should respect the renewed and comprehensive perspective of lifelong learning needs sustained by the Agenda.

2.4.3 Cost drivers for financing the hybrid learning ecosystem

For hybrid learning, critical infrastructure and connectivity elements need to be in place in order to implement digital learning policies, as do the pedagogical and human resources associated with transitioning from current delivery modalities. Such items and their costs can generally be grouped into seven categories. A brief description is presented here for each.

1. *Telecommunications infrastructure and the regulatory environment*

At present, a major barrier to hybrid learning is the lack of infrastructure and affordable connectivity to link schools and households. Below is a summary of the three key considerations, and more details are provided in section 2.5.

Telecommunication and energy infrastructure: Major technologies compatible with the connectivity requirements are fibre, local WISP-operated networks, 4G, 5G, satellites, or combinations of these. Investments will depend on the degree to which these technologies are extended between and even within countries.

Connectivity (bandwidth) requirements: The hybrid learning ambitions require mobile or fixed technology that provides educationally meaningful internet speeds. The bare minimum requirement for the types of activities that teachers and students will likely engage in are 100GB of data and 10 Mbps download speed – 10 Mbps per school or 1 Mbps per 20 students (for larger schools). Procurement processes should stipulate the service level needed, e.g. 10-20 Mbps.

Number and profiles of schools in need of connectivity: The size of the investment required for the hybrid learning transformation will depend on the number of schools that need to be connected or need upgraded coverage (for example, from 3G to 4G). Even the schools' dispersion and size will matter for the investment. These schools will tend to be in rural, remote areas or islands in many countries, and such schools are complicated and costly to connect. Likewise, connectivity costs are fixed, and schools serving a larger number of students will drive overall costs down while smaller and dispersed schools will push costs up. School data can be provided by the education ministry or other government agencies.

2. *Investments needed in digital skills*

To support infrastructure and connectivity adoption goals, there are calls for funding the 'soft' elements. The ITU estimates that 11 per cent of the finance to connect all of humanity will have to be dedicated to developing or strengthening users' ICT skills, relevant content, and policy and regulatory frameworks (ITU, 2020a). These elements are part of strategies to stimulate the population's demand and use of the internet, e.g. to access and utilize information to make informed decisions.

3. *Learning devices and classroom equipment for students and teachers*

Another cost driver for implementing hybrid learning is the devices needed for access. It is clear that for low-resource contexts, lacking computers or internet access, financing provision is imperative to allow for school- and home-based learning under hybrid models. There are various strategies to address this need.

In the past, investment in educational technology represented a high share of the costs of ICT interventions. However, the prices of computing devices like desktops, laptops, tablets and smartphones have been going down steadily.[10] Other devices like projectors, smart boards and smart TVs (and even printers) will also be needed. This expenditure could include devices for teacher training, although in many examples, the preference can be to separate out training costs.

A special note about home devices is warranted, as discussed in Chapter 1. Relying on students' ownership of devices poses an equity challenge, as many households cannot afford devices or home internet access, especially in remote and rural areas. Under the principles of free basic education, governments should supply high-quality devices for households that cannot afford them. Box 20 presents the component costs incurred in supplying devices.

10 The price of smartphones, for example, has declined steadily over recent years, but in some countries, the cheapest device can reach a quarter or more of the monthly household income (A4AI, 2020b).

Box 20. What are the component costs incurred in supplying devices?

When examining the total costs of devices, governments should have in mind the following considerations:

- Device type and technical specifications: The costs of devices will vary depending on their type (i.e. brand and model) and technical specifications (power, battery life, screen size, interface, etc.). The choice of the device should also be based on accessibility issues for learners with special needs.
- Peripherals, such as keyboards, protective screens and cases.
- Software licences that need to be purchased or rented, and their support packages.
- Devices and equipment maintenance and upgrades.
- Insurance and service contracts.
- Security- and cybersecurity-related expenses.
- Device depreciation rate and useful life: Devices lose value the more they are used, and they will need to be replaced (usually every three to five years). .

Source: Adapted from US Department of Education (2017a).

4. *Curriculum alignment, digital content and OER platforms*

The fourth type of investment required for operationalizing hybrid learning relates to alignment with the curriculum and digital contents, e.g. teaching, learning and other instructional resources organized and curated within online repositories.

Curriculum alignment: In general terms, digital materials are more relevant and robust when aligned with the national or government curriculum. In this process, certain curricular decisions related to the digitalization process have cost implications. For example, digitalizing content for specific subjects or grades will take less effort and budget than digitalizing the entire national curriculum. It also appears less costly to align and adapt content from a non-digital to a new hybrid learning curriculum than to develop digital content for two separate curricula (GEF, 2021b). Finally, many educational materials will need to be translated into local or indigenous languages.

Digital content: Meanwhile, digital content is already replacing traditional textbooks and materials in many countries, including online courses (like MOOCS), digital textbooks, images, videos, student assessments, library licensed materials, self-developed materials, or a combination of these. There are three main types of digital content, with access and design influenced in part by their costs (US Department of Education, 2017b). Table 4 provides an overview of these, along with their potential cost considerations.

Table 4. Types of digital content and cost considerations

Types of digital content	Cost considerations
OERs: They are in the public domain or released with intellectual property licences that facilitate the free-of-charge use, adaptation and distribution of resources. **Free digital learning resources:** They are free, but copyright restricted and require permission from the owner or creator for their use or repurpose. **Proprietary digital textbooks:** They are 'privately' owned by commercial publishers, copyright restricted, and have varying costs. They cannot be used and disseminated freely.	**Development or adaptation** • Type, quantity and extension of the digital materials to be developed, adapted and/or translated (including periodic updates to the materials). • Number and type of teachers/experts and hours needed to develop, revise, curate and translate materials and conduct curriculum alignment evaluations. • Licences and subscriptions. **Infrastructure** • Hosting (server, DNS filtering) and dissemination costs. • Repositories of instructional materials.

The pedagogical and quality considerations regarding digital content are plentiful and have already been laid out in Chapter 1. The Broadband Commission (2020b) has also presented an approach for identifying and deploying high-quality content, solutions and platforms. It consists of three steps: (1) identify and assess, (2) increase access, and (3) deploy and use. These considerations should be placed high in the hybrid learning investment discussion and cost analysis.[11]

OER platforms: According to UNESCO's Recommendation on OERs, governments and education stakeholders are encouraged to develop national OER policies. Digital content should be accessible and free-of-charge, particularly for disadvantaged or displaced pupils. For example, in low-resource or rural settings, it must be available to use for free and offline. Devices should be preloaded with appropriately adapted hybrid learning materials to last at least one school year (UNESCO, 2021a).

OERs contribute to reducing licensing costs, allowing for freely using, sharing, replicating, and editing educational materials (US Department of Education, 2017a). OERs have the potential to reduce public expenditures and generate savings that can be used for other educational purposes. They eliminate the printing, delivering, copyright and licensing fees of hardcover textbooks. Second, developing and curating digital content costs less than traditional textbooks. For example, the US Department of Education (2017b) estimates that teacher time and salaries for digital content development cost about a third of what traditional static books cost. Third, savings are also seen for higher education. Still, the governmental decision to transition to digital content must rely on the pedagogical advantages — the quality of the material has to be safeguarded.

11 See also McGreal, Miao, and Mishra (2016) for other non-financial reasons for transitioning towards OER.

It should, however, be underlined that OERs have cost implications. The creation, adoption, adaptation, curation, hosting and dissemination of OERs require some financial provision, mainly for the teachers and experts. In addition, the cost of developing the OER infrastructure can also be high. Nonetheless, the emergence of OERs may provide a welcome relief for families and learners in light of the rising prices of textbooks, which have become unaffordable for many households. Buying course textbooks can also be a barrier at universities, as often these costs are not accounted for in the scholarship systems.

5. *Investments in people: Education workforce and teachers' professional development*

Implementing hybrid-learning models will require significant adjustments to teaching and learning alongside communication and collaboration tools in the form of devices, software, and digital content.

All of this also has general cost implications for teachers and personnel, including salaries and fringe benefits. Human resource costs may further include managing the school and community networks and providing technical support for teachers, staff, consultants and third-party vendors who assist with technology planning, configuration, testing, and maintenance.

But this should not be surprising. As is the case in education financing in general, salaries are usually the largest expenditure. This will undoubtedly continue to be the case for hybrid learning, particularly when devices have become more affordable and infrastructure investment projects (buildings and telecommunications) are accounted for in the portfolios of other sectors.

6. *School infrastructure*

The school infrastructure is another important item in hybrid-learning investment plans. Some buildings may need to be renovated or upgraded, and some additional classrooms or computer labs may have to be built, depending on the hybrid strategy to be implemented. Some rotation models, for example, are classroom-based but assume that the space is big enough to arrange students in groups simultaneously. In addition, certain devices require good ventilation, and in some countries, investment will be needed up front to secure the classrooms and equipment.

The quality and minimum standards of the infrastructure are further crucial elements in SDG 4 and the Education 2030 Agenda (UNESCO, 2015). The construction and adequacy of school facilities are included in SDG 4 as a means of implementing the educational goals. States are committed to building and adapting school facilities to respond to children's needs and provide an environment conducive to hybrid learning. Under international law, states have a legal obligation to ensure that educational institutions are safe and facilitate a quality and inclusive learning environment.

7. *Other operational costs: Electricity, maintenance, etc.*

Finally, much of the implementation of hybrid learning models depends on schools' and educational institutions' capacity to afford the recurring operational costs. Therefore, electricity, computers, technology, and continuous upgrading, maintenance and repair of devices are required, and governments should not forget to support schools and teachers.

■ *Overall*

All of the above reinforces the **need for parallel investments** in the hybrid-learning ecosystem. Countries such as **France** have taken the approach of investing in the entire hybrid learning system (see the Compendium), focusing on an integrated, proactive digital policy, including investments to make digital resources (kits) and equipment available to pupils and teachers, and train teachers and parents in digital skills.

Regardless of the approach taken, financing, infrastructure and investment are required in all elements of the hybrid-learning ecosystem to ensure medium- to long-term sustainability (GEF, 2021a). Technologies and models must be integrated into the classroom or into new learning arrangements to complement and improve teaching; otherwise, they will simply be expensive add-ons.

2.4.4 Potential funding sources

As indicated previously, self-sustaining financing of telecommunications infrastructure will likely require direct and indirect funding from a combination of providers and sources, both for the rollout capital and operational/recurring investments. Different obstacles (infrastructure, devices, digital content, teacher training, etc.) can be addressed through different financing models. This would require close coordination and cooperation to ensure that levers are being pulled in tandem. Medium- to longer-term adjustments can be met through several financing arrangements and stakeholders' contributions where partners work together to mutualize resources and reduce the costs involved in tackling more embedded challenges.

When selecting appropriate financing models, governments should assess conditions in the broader ecosystem and seek to ensure that equity orientations are at the core of decision-making. There may be several routes to this goal, including adjusting resource allocation to compensate schools and students in low-income, disadvantaged and rural areas, e.g. through weighted resource allocations, subsidies and grants to purchase equipment or devices (UNESCO, 2021c).

There are many examples of government funding being diverted to support disadvantaged schools, students and families who lack access to mobile devices and internet data. For instance, in Scotland (**United Kingdom**), funding under a technology programme is allocated proportionally to local authorities, through a formula based on deprivation and rurality. Funds can be used to provide devices, improve connectivity, hire additional staff and even provide support to households.

This sub-section takes a closer look at different potential funding arrangements for different parts of the hybrid learning ecosystem.

■ *For infrastructure*

Section 2.5 discusses several approaches (or archetypes) for connecting schools to the internet: government-contributed, commercially provided and community-based funding.

■ *For digital skills development*

Investments could draw from government funds, development aid, multilateral banks and innovative financing mechanisms. Specifically, the skills and content costs represent nine per cent of the total estimated investment. They include per-user costs for training and content, like establishing tech hubs, local content ecosystems and internet-literacy training programmes. According to UNESCO (forthcoming) more than 70 countries have set up training funds, the resources of which can be used to invest in upskilling and reskilling.

■ *Towards the availability of devices*

The financing of devices can come from contributions from different stakeholders, in addition to the government. There are various investment models for providing computing devices (US Department of Education, 2017a):

- **Government purchase:** In this model, the government owns the devices and might purchase a warranty-of-service agreement from the manufacturers or retailers for repair and/or replacement. This model requires that governments account for the costs of upgrades.

- **Leasing/subscription:** Devices can also be leased or rented out, and the costs typically include upgrade options.

- **Cooperative purchasing:** This approach is more feasible in decentralized countries and local school districts (for example, in the **United States**). Devices are purchased through regional, state or consortium-based contracts and vendor competition, which offer discount pricing for large-quantity purchases.

Some governments allocate a portion of their infrastructure funds (collected through Universal Service Access Funds or other financing mechanisms) to support the affordability of devices and internet access. Around the world, more than 100 countries have some form of USF (either planned or operational) created to narrow the digital divide. Those funds are mainly collected by levying operators. Operators tend to pay a stipulated percentage of their annual gross revenue (AGR) to a regulator or government agency in charge of universal service as part of their obligations. The levy can result in considerable funds being left with the government. The experiences of **Morocco**, **Pakistan** and the **United States** stand out, and they are summarized in the Compendium.

In addition to the USFs, to finance the learning devices, governments may also have recourse to alternatives such as:

- micro-financing of devices;

- reduction in taxes and import duties on devices and usage of services;

- reduction of or exemption from patent royalties;

- aggregating demand for devices;

- providing subsidies to reduce costs; and

- re-use of discarded devices from developed countries.

Some countries have subsidized the purchase of devices, provided laptops for free, and/or financed free access for students (see Box 21). Some organizations have also distributed refurbished or recycled computers. Others use devices or applications that allow students to work offline, provide connectivity on buses, or encourage arrangements with the local community (through libraries, community centres, clubs, etc.).

Box 21. Spotlight on government policies to make devices more available

The turn to remote and digital learning options, as a result of COVID-19 restrictions, prompted governments to provide or subsidize devices for learners and educators. Two provincial governments in **Canada**, for example, announced investments in educational devices to support learning. Nova Scotia declared that elementary and secondary students would receive new Chromebooks under the Back-to-School Programme, and schools would receive Wi-Fi servers and routers, thanks to an investment of $21.5 million. Newfoundland and Labrador, on the other hand, purchased laptops for teachers and Chromebooks for high schools. The devices were distributed through the public procurement process. The national government of Canada also invested $15 million in high-speed internet and broadband connections to offer support to post-secondary students from low-income households and other disadvantaged groups through after-school activities and online mentoring services. This is called the Support for Student Learning Programme.

In collaboration with the Ministry of Communications and Information Technology and other suppliers, the Ministry of Education of **Saudi Arabia** supported disadvantaged university students, providing free laptops, tablets, internet, and access to platforms and websites.

German funds for the initiative *Digitalpakt Schule* show a policy to support home learning in an intergovernmental fashion and ensure that all pupils have access to mobile devices. While the federal government provides most of the investment, the state governments (Länder) contribute a portion of the investment and supervise the implementation.

The Compendium gives more examples of governments opting to make devices and internet accessible to schools and homes in one way or another. See, for instance, the cases of the programmes The Connected Students Project (**Brazil**), Get Help with Technology (**United Kingdom**), and the Everybody Learns Initiative (the State of Connecticut, **United States**).

Source: G20 Italy (2021) .

- *To access digital content*

Traditionally, curricula and instructional materials development are expenditure items within the ministries of education (national, state or local). In the hybrid learning space, complementary and alternative funding arrangements are emerging that support access to digital content, including the collaboration and engagement of communities, state and non-state stakeholders, institutions, and international donors. In addition, there are numerous potential arrangements for public-private partnerships, and the collaboration or participation of private providers and even non-profits in the financing of digital content.

- **Zero-rating policies:** Mobile phone companies contribute through zero-rating educational content (see Chapter 1). This refers to an arrangement where mobile operators do not charge for the data used for educational purposes. There is a movement to ease the costs of accessing digital content under zero-rating initiated with the Wikipedia Foundation called Wikipedia Zero, offering access to information via text messages at no charge (Trucano, 2016). The movement seems to be expanding to educational content on the internet at zero bandwidth costs. These kinds of agreements have been growing in prevalence throughout the pandemic. The ministries of education in **Colombia**, **Nigeria** and **South Africa** were ahead of the game when COVID-19 struck, signing agreements with mobile operators to ensure that the data needed to access the education portals was charged at a zero tariff (see the Compendium). In **Colombia**, for instance, the service was enabled under the Colombia Learns Mobile programme up to a predefined cap. Its success is related to a close collaboration between the education and ICT sectors.

- **Support through social network platforms:** These platforms have facilitated content development and distribution, generating many controversies related to the view that charging some users for content but not others might be a discriminatory commercial practice, violating the principle of net neutrality.

- **Private and foundation funding support from non-profit organizations:** The African Storybook Initiative (launched in 2014) provides contextually and linguistically appropriate materials for early reading. The initiative develops, publishes, and uses storybooks that are readable online or offline for free, and can be downloaded and printed (African Storybook, 2021). Once a platform was established, there were minimal costs incurred in gathering, curating and translating the stories.[12]

- **Innovative funding models for educational institutions to develop OERs:** Institutions have also contributed to financing OER efforts, particularly in higher education. For example, in **Australian** and **Canadian** higher education systems, open educational practices relied initially on support and funding from the national and state governments (Bossu, 2016; McGreal, Anderson, and Conrad, 2016). As the digital transformation evolved, some universities and institutions have managed to stay atop the heap, developing, improving, and financing the infrastructure and producing resources for their faculty, staff, and students. As the **Malaysian** Wawasan Open University case shows (see the Compendium), there are different models for university involvement: using proprietary course materials under licence, producing stand-alone materials, and developing OER under the 'wrap-around textbook model' (Liew, 2016, p. 125). Many MOOC suppliers do not necessarily open the content, but just signal the transfer of copyright ownership from universities to commercial providers (McGreal, Anderson, and Conrad, 2016). The government policy, financing and legal frameworks are essential, particularly when there are many institutional or commercial players (see Box 22).

12 The total costs of a story benefiting thousands of young readers can reach $1,450, once the platform has been developed (Welch and Glennie, 2016).

Box 22. A proposal for donors to fund OERs

Under the GEF, several proposals are being considered to support the expansion of digital learning to accelerate progress towards SDG 4. One proposal is to establish a special initiative on OER to improve access to digital learning tools. The initiative also includes print-based resources.

Members of the GEF would commit funding for two areas: (1) the development of high-quality OERs in relevant languages, making sure they align with and cover the national curriculum; and (2) support for ten countries to roll out digital curriculum practices at their education ministries and leverage the OERs. At the core of the donor proposal for support is the aim of exploring synergies and economies of scale in developing OERs. The funding would initially collect an estimated $60 million to promote access to teaching and learning resources.

Established in September 2019, the GEF is a forum, convened and supported by the Education Commission. It brings together high-level leaders from key donor countries and multilateral institutions to improve 'international collaboration and advocate for increased and more effective investment in global education'.

Sources: GEF (2021b); Education Commission (2021).

2.4.5 Cost simulation as an evidence-based national policy and investment tool

UNESCO supports governments by facilitating policy dialogue and provides technical assistance to strengthen education systems and sector-wide education policy formulation and planning. To this end, it has developed and adapted tools to simulate the costs of investment in hybrid learning delivery and engagement for advocacy and policy dialogue (Chang, 2006; UNESCO, 2005, 2007, 2012, 2021b).

This section presents a sector-wide costing model that does not intend to be prescriptive. Instead, it is a tool to facilitate analysis of the implications of resources (human, technical, and physical) to deploy hybrid learning depending on equity, inclusion and gender equality goals, pedagogical options, and investment opportunities.

The model includes consideration of the main non-digital infrastructure cost drivers in education (e.g. teacher salaries and school infrastructure) and other fundamental expenses of the hybrid-learning environment. Cost simulations for investments in telecommunication infrastructure are presented in this section.

Other agencies like the ITU have also provided investment estimates related to global connectivity infrastructure and adoption (see Box 23).

Box 23. Estimated investment needed to connect humanity by 2030: The ITU's approach

In 2020, the ITU estimated the investment needed to achieve universal access to broadband connectivity by 2030. The approach uses the number of unconnected users as the foundational baseline, approximately three billion people aged ten years and above. The majority are in Africa and South Asia. It provides additional capital and estimates of operating expenditure. The approach also considers infrastructure and non-infrastructure needs, the latter reflecting the costs to provide the optimal contexts for connectivity deployment and use: (1) ICT skills and content; and (2) policy and regulations. Furthermore, the model is based on a sample of 218 countries and economies. A detailed description of the approach and methodology can be consulted in the ITU's report.

According to the estimates, the world would need to see an investment of about $43 billion annually in order for the population aged ten and above to have access to broadband connectivity (approximately $428 billion by 2030). The structure of the investment requirements varies roughly by country and level of economic development. Still, the largest share of the overall investment is for rolling out and maintaining broadband networks (89 per cent), of which 58 per cent are operational costs (network operation and maintenance plus remote area coverage) and 43 per cent capital expenditures (mobile radio network and metro and backbone fibre/network backhaul).

About 11 per cent will be needed for developing or strengthening ICT skills and relevant content and establishing policy and regulatory frameworks. It includes: training and content (establishing tech hubs, local content ecosystem or internet literacy training programmes) and regulation to promote cost-effective infrastructure rollout, lower connectivity retail prices, and increased broadband usage.

Source: ITU (2020).

Although the results are based on country-level connectivity needs, the ITU's approach with its focus on wider societal needs differs and rather complements the sector-wide educational perspective taken in this report. An investment analysis specific to the education sector will require consideration of inter-sectoral policies and regulations affecting not only the infrastructure but also other elements of the ecosystem, like the role of governments and partners in the distribution and use of devices or the development and curation of digital content. A cost simulation for the education sector necessarily includes the expenses for additional teachers, teacher training, and school labs — elements left out of other estimates given that they centre on the population's connectivity and not on educational development and hybrid learning needs.

In spite of their differences, the estimation approaches concur that the interventions necessary for the adoption and use of broadband connectivity require investment beyond the broadband infrastructure, whether for the population and communities or educational institutions, educators and learners.

■ *The estimated costs of investing in hybrid learning: Simulation for two countries (Honduras and Sierra Leone)*

As a demonstration of its practical application, the model estimates the potential costs of implementing hybrid learning within a sector-wide approach in a simulated scenario for two countries (**Honduras** and **Sierra Leone**). It exemplifies one possible implementation scenario of the resources required and their use for the expansion of hybrid learning. It covers primary to upper-secondary general education, ISCED 1 to ISCED 3 (and assumes that hybrid learning is inappropriate for pre-primary).[13]

The sector-wide cost simulation model developed by UNESCO is based on the following parameters:

- **Data**: National data are used. They have been extracted from the simulation models already used by countries for education sector plan development. International open data is used if national data are unavailable (e.g. the International Monetary Fund, IMF, or the UNESCO Institute for Statistics, UIS).
- Assumptions:
  - Countries will achieve a 100 per cent gross enrolment ratio (GER) for primary and lower secondary and improve GER for upper secondary by 2030.
  - All schools will be considered for the hybrid learning policy, regardless of their ownership (e.g. government, community, private).
  - Other cost items or resource use will remain constant (e.g. teacher salary, class size, unit costs).
  - There is no hybrid learning before 2021.
  - Hybrid learning will be progressively expanded to reach 10 per cent of students in primary, 20 per cent in lower secondary, and 30 per cent in upper secondary by 2030.
  - The depreciation rate of classroom equipment and devices is set at 20 per cent (replaced every five years).
  - Schools' equipment, telecommunications infrastructure and data are not included because these items appear in the cost simulations for infrastructure.
  - Trade-offs or efficiency gains are not shown, but they can also be calculated to simulate the net cost.
- Costed items:
  - Devices (tablets for primary, laptops for secondary): An estimated $200 is considered for tablets and $400 for laptops.
  - Classroom equipment (e.g. displays): Estimated at $1,000 for primary schools and $2,000 for secondary.
  - School technician (one full-time technician for each school conducting hybrid learning): The model uses national teacher salary data as a percentage of the GDP.
  - Curriculum and content development and curation: The model assumes that developing, adapting and curating digital content costs $100,000 for primary and $150,000 for secondary in Sierra Leone, and $200,000 and $300,000 in Honduras. Furthermore, it assumes that expenses for digital content will be accrued for the period 2022-2024 only.

13 ISCED is the International Standard Classification of Education (UNESCO-UIS, 2012). ISCED 1 refers to primary education and ISCED 3 to upper secondary.

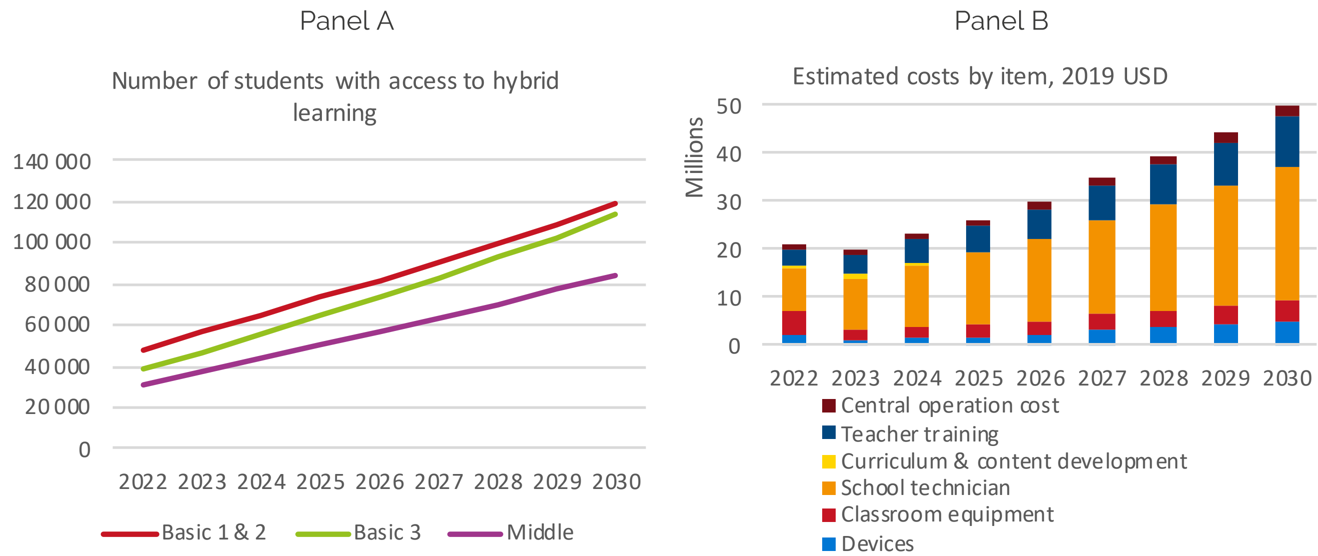
- Teacher training: Unit costs for this are estimated as a percentage of the teacher's salary (in GDP/capita multiple), five per cent for Honduras and seven per cent for Sierra Leone.
- Central operation cost: Operational costs are assumed to be five per cent of the total costs. This would include running learning and management systems, monitoring and evaluation, and other expenses related to the policy and planning process (i.e. sector plan development, policy dialogue, and regulatory frameworks).

The estimated costs of implementing hybrid learning are shown in Figures 9 and 10. The results are hypothetical and need to be adjusted based on updated country data and, most importantly, if the model's assumptions change.

Honduras

The total number of students (three levels of education) with access to hybrid learning will increase 1.7 times from about 119,000 to 317,000, although the proportion of students with access remains constant. This is because the model assumes that the country is set to achieve universal primary (basic 1 and 2) and lower secondary (basic 3) education by 2030, and an improvement in school participation for upper secondary (middle).

Figure 9. Honduras: Estimated number of students with access to hybrid learning and estimated costs



Source: UNESCO hybrid learning simulation model.

The total costs required to implement hybrid learning amount to **$239 million** (using 2019 values) between 2022 and 2030, or about $30 million annually (panel B), excluding connectivity costs. The primary cost driver is the school technicians (about 55 per cent of total non-infrastructure investments), due to their salaries being high in terms of GDP per capita. The model assumes that technicians have the same salary as a science or computing teacher, amounting to about six to seven per cent of the GDP per capita, according to the national data. The second cost item taking a large share is teacher training, representing about 20 per cent of the total investment required from the education sector (again, excluding infrastructure).

Overall, implementing hybrid learning in Honduras would require an investment of **$17 per student annually** (without connectivity costs), calculated for each student in the system and not only those benefiting from hybrid learning.

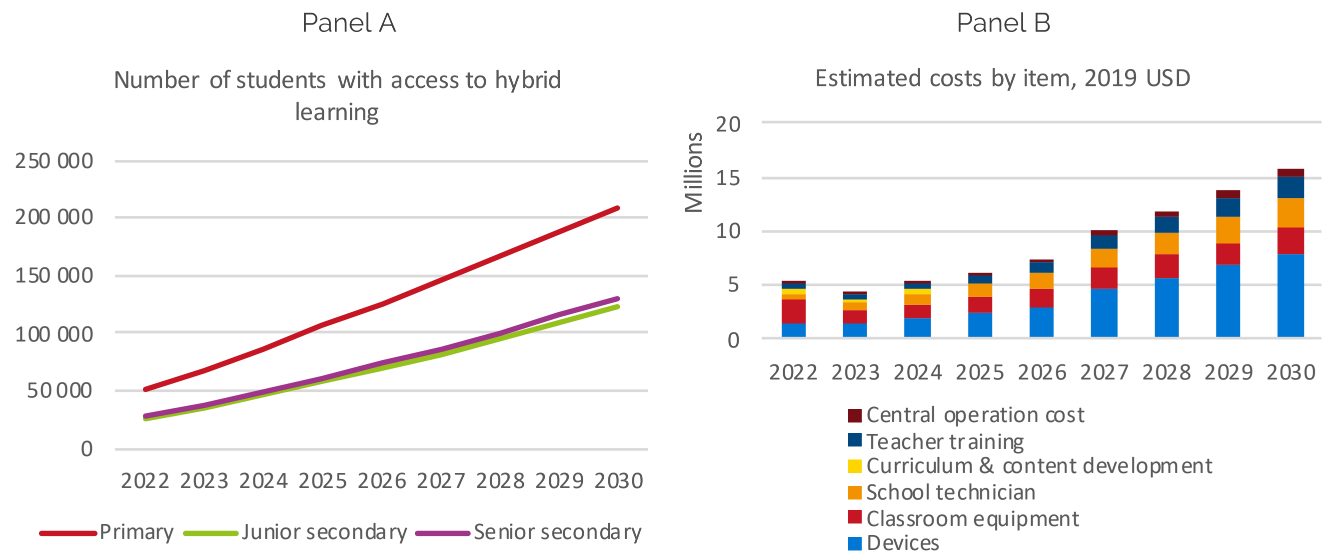
Sierra Leone

In total, about 462,000 students will have access to hybrid learning by 2030, an increase by a factor of 2.3 (see Figure 10, panel A), which is much higher than the factor for Honduras. Sierra Leone is further behind than Honduras on the GER, and neither country is on the hybrid learning access target.

The second panel (B) in Figure 10 shows the estimated costs of implementing hybrid learning, excluding connectivity. Between 2022 and 2030, it is estimated that a total of **$80 million** would be required, about **$10 million annually**. The major share is needed for the devices (44 per cent),[14] followed by classroom equipment (21 per cent) and the school technician (17 per cent). Compared to Honduras, teacher salaries in Sierra Leone are lower (about three per cent of the GDP per capita).

Overall, the hybrid learning investment needed in Sierra Leone (excluding connectivity) is estimated at about **$3 a year per student** in the system (not only those benefiting from hybrid learning).

Figure 10. Sierra Leone: Estimated number of students with access to hybrid learning and estimated costs



Source: UNESCO hybrid learning simulation model.

14 Devices tend to be unaffordable in Sierra Leone. The simulation model assumes that only tablets and laptops will be required to implement hybrid learning. As a side note, it is useful to know that the cheapest available smartphone costs $265.20, about six months' salary for the average person (A4AI, 2020b).

2.5 Infrastructure investments and finance models

Costs are influenced by choices made regarding technology, operational model, and funding structure (see Figure 11).

1. Technology

A wide variety of factors determine the capital expenditure ('capex') and operational expenditure ('opex') needs for each school. First, in terms of technology, a key determinant of capex and opex needs is the required internet speed for the school. In line with Giga, it is recommended that this equals a minimum of 20 Mbps, and certainly no less than 10 Mbps. If a school or government aims for a better connection, this would allow for higher-quality education; however, it can also significantly drive up costs. Although it is encouraged to aim for more speed, the sustainability of the intended solution needs to be considered. A second determinant of technology is the number of students per school. The internet speed target generally needs to increase the larger the size of the school. Third, hundreds of small schools are more expensive to connect than two large schools, even if the same number of students must be connected, so the number and dispersion of schools is also a determinant. Fourth, the school's connectivity starting point is relevant in ascertaining costs. For example, many schools in Brazil are connected, but 14 per cent of schools have <5 Mbps, and therefore do not meet the cut-off point for meaningful connectivity as set by Giga. Electricity penetration is another key determinant of technology cost. In Rwanda, 33 per cent of all schools are off-grid, and therefore connectivity costs need to include electricity. In countries with unreliable electricity, such as Honduras, alternative technologies like solar and lithium batteries could be considered. Finally, the remoteness of the school is a determinant, as remote schools are harder and costlier to connect than urban ones. Remote areas unfortunately often go hand-in-hand with lower potential revenue generation, thereby increasing the difficulty of finding a sustainable funding method. This sometimes means that public intervention is needed to make sure no one is left behind.

2. Operational model

A key driver of costs is the type of party carrying the operational responsibility. In some countries, e.g. Brazil, large service providers (SPs) can work together with a long tail of somewhat smaller third-party ISPs, who can operate at lower costs in specific regions. Local electricians can also be leveraged. Another cost determinant is the partnership model, where private sector involvement is generally correlated with better financial performance vis-à-vis operational execution by a governmental institution.

3. Funding structure

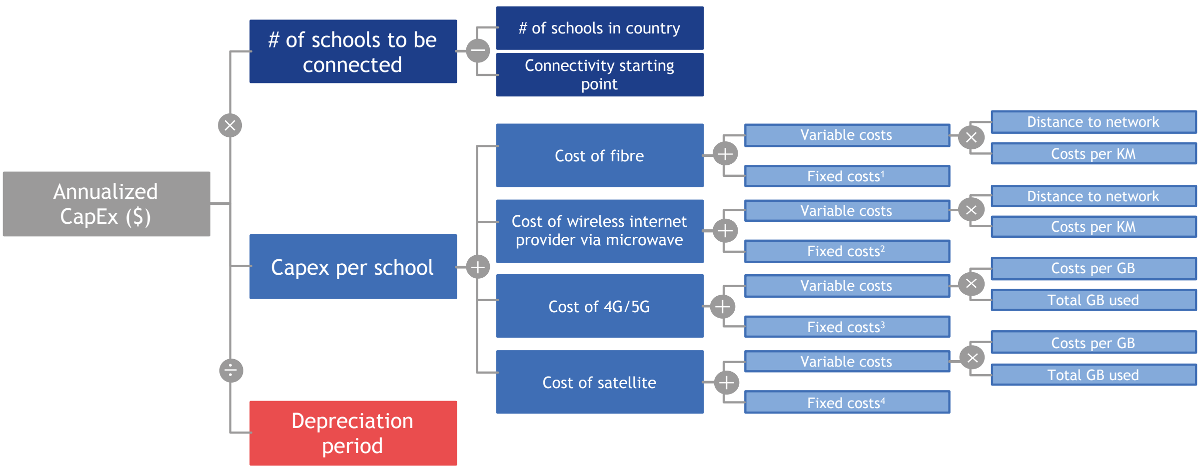
In terms of funding structure, capex and opex are influenced by the type of funding partner involved. Working together with experts, e.g. SPs, may provide lower costs due to scaling advantages, whereas working with infrastructure investment funds provides fewer such benefits.

Figure 11. Key determinants of infrastructure connectivity costs

Dimension	School's values		
Technology			
Internet speed target	5-10 Mbps	10-20 Mbps	≥20 Mbps
School size	Small (<200 students)	Medium (200-500 students)	Large (>500 students)
Client groups	School only		Community
Connectivity starting point	Above minimum (10 Mbps)	Yes, but too low (<10 Mbps)	No
Electricity penetration	Yes, trustworthy	Yes, but not trustworthy	No
School remoteness	Remote	Rural	Urban
Operating model			
Operational responsibility	Telecommunications comp.	Local electricians	Service Providers
Partnership model	Public	Public & private	Private
Funding structure			
Funding partners	Government only	Community	Commercial

The capex and opex amounts are driven by different factors. For capex, a key driver is the number of schools that require connecting and the average capex per school, which is in turn dependent on the type of connectivity technology used. Given that the number of schools that require connectivity is the key driver of capex, countries with a better starting point, such as Brazil or Rwanda, will tend to require less capex than countries like Honduras and Sierra Leone, where over 90 per cent of schools do not have any type of connectivity. As described earlier, fibre is one of the future-proof fixed access technologies, but it can be commercially challenging to deploy, particularly in lower-density, topographically challenging, and low-income areas. The upfront costs (capex) of fibre are significantly higher compared to all other technologies, although the depreciation period is much longer. In countries such as Rwanda where the fibre backbone is already quite strong and most schools are within proximity to an existing fibre connection, fibre and WISP could be logical connection methods. Contrarily, no additional 4G network would need to be rolled out as 95 per cent of the country is already covered. As a result, weighted upfront capex costs per school vis-à-vis other countries are relatively high, due to larger initial capital requirements for fibre. For other countries, such as Honduras, working with a combination of 4G, WISP and fibre leads to lower weighted upfront capex costs per school, all else being equal. In countries such as Brazil, the cost of connecting schools differs tremendously per region. For example, connecting schools in the Amazon, where little fibre backhaul exists, is dramatically different to connecting schools in urban areas in southeast Brazil surrounded by fibre and WISP opportunities. This will lead to very different capex and opex costs (see Figures 12 and 13).

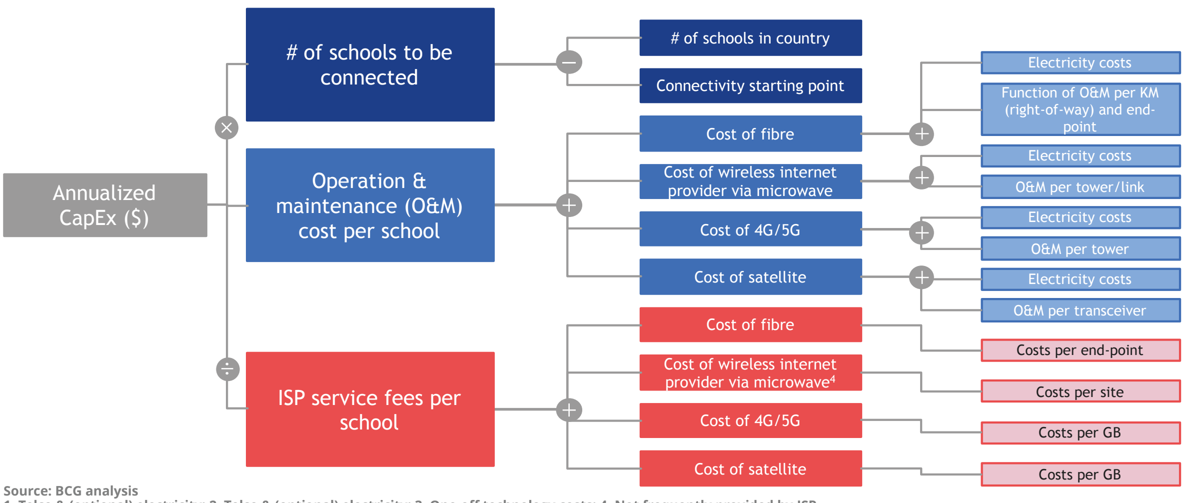
Figure 12. Annualized capex driver tree



Source: BCG analysis
1. Telco & (optional) electricity; 2. MNO/ISP & (optional) electricity; 3. E.g. Install 4/5G modem equipment and cabling to receive cellular signal and share internet connection via (W)LAN); 4. One-off technology costs

Like capex, opex is also driven by the number of schools to be connected. Another key driver is either 'operation and maintenance costs per school' or 'ISP service fees per school', depending on the operational model in use. It is also important to consider the cost per bit for the technologies, as decision-makers may balance costs using this figure.

Figure 13. Annualized opex driver tree

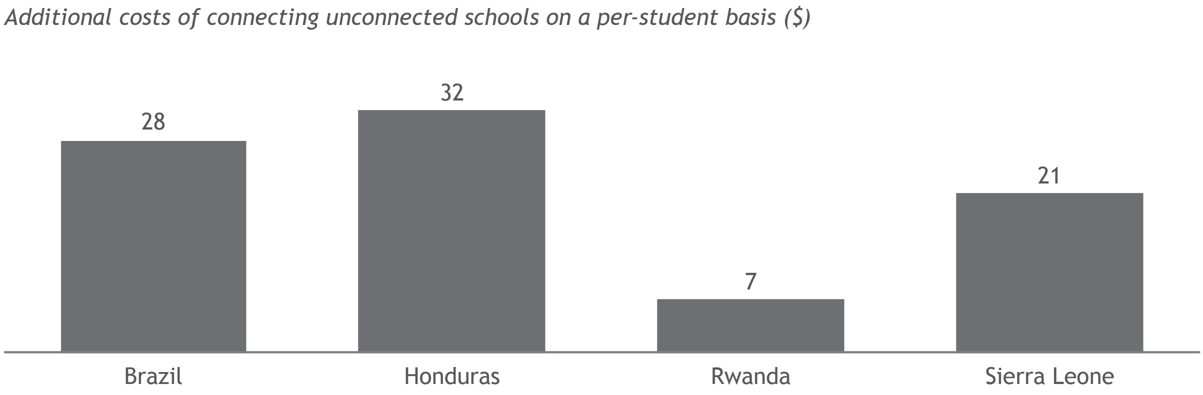


Source: BCG analysis
1. Telco & (optional) electricity; 2. Telco & (optional) electricity; 3. One-off technology costs; 4. Not frequently provided by ISP

For Rwanda, an additional ~$7 per year would be required per student yet to be connected. In contrast, for Honduras, a significant ~$32 per year per student would be needed. Although the costs per school are relatively similar between the countries, the number of students per school is significantly lower in Honduras (~100 vs ~400). As shown in the opex driver tree, the number of schools is a key driver of costs, thereby increasing the overall funding needs for Honduras. In addition, its existing infrastructure is worse than Rwanda's, thereby increasing the last-mile connectivity costs. Sierra Leone's expected cost to connect is an additional ~$21 per student, in between Honduras and Rwanda.

Although existing connection levels in Sierra Leone are low, in line with those of Honduras, the average class size is almost double that of Honduras. Finally, for Brazil the average additional cost per year per student is ~$28.[15]

Figure 14. Costs of connecting schools per student



2.5.1 Funding models

This section differentiates between (1) contributions, that are considered to be ongoing, mostly opex; and (2) investments which can be used for upfront costs, mostly capex. Together, these are referred to as 'funding'. There are four potential sources of sustainable funding, of which three can be stable and sustainable in the long term (see Table 5).

The first type of funding for connectivity infrastructure can come from the **government (public funds)**. Such funding can be made available, for example, through an additional budget from the education department, contributions from other ministries (e.g. infrastructure, ICT, or energy), or savings from other budget lines as a result of added connectivity.[16] Working together between different departments of the ministry is imperative to make this type of recurring funding stable. If the government can provide dedicated funds on an ongoing basis, without a (significant) risk of discontinuation in case of a change in government, this measure is considered to be sustainable. Oftentimes, this implies that the smaller the government contribution to connectivity vis-à-vis the overall education budget, the less likely it is to be cut unexpectedly. There may also be scope to discuss such funding together with multilateral lending that the government may be receiving. While this comes with some challenges, it could also provide options related to outcome financing and the country's overall development programme.

The second type of funding that can be sustainable in the long run is funding from **commercial strategic partners**. This can be through fully commercial business models, as often seen in developed nations; through mandated cross-subsidization by the government (e.g. a portfolio of easy- and hard-to-connect schools); or through innovative

15 This is preliminary as the final division of technology is being optimized.
16 After connecting many schools, the Kyrgyz Government has saved 40 per cent of its annual education connectivity budget due to negotiations on fees with service providers.

business models like advertisements for public or subsidized usage of the internet.

The third type of funding is **community cost sharing**. Though a recurring contribution can come from communities, it is unlikely that upfront investment for capex can be provided without support, given typical affordability issues. In this model, the community is responsible for paying for the school's connectivity. This can be done directly via an increase in school fees or a direct connectivity provision (Wi-Fi public hotspot). Alternatively, it can be done indirectly, through non-school service fees (growth in consumer demand for connectivity will recoup the cost of connectivity investments) or through local and regional business growth that leads to increases in profits and start-ups and thereby to more tax revenue. This model is sustainable when it is both (1) affordable according to the ITU's guidelines, which stipulate two per cent of GNI per capita; and (2) long-term in nature, with respect to the network. In order to do so, there have to be enough volunteers willing and able to work on the network, and succession plans in place for when volunteers can no longer contribute. The long-term retention of skilled volunteers is often challenging, and difficulties in this regard can form a barrier to large-scale rollout.

Finally, financing can be donor-funded through **NGOs or non-profits**. This type of funding cannot be provided on an indefinite basis and is therefore considered to be unsustainable in the long term. Nevertheless, it is indispensable (especially in the short-to-medium term) for many regions that are working towards full connectivity for their schools and can potentially provide valuable first-loss type capital or other risk mitigation capital which could then be used to mobilize other sources of funding.

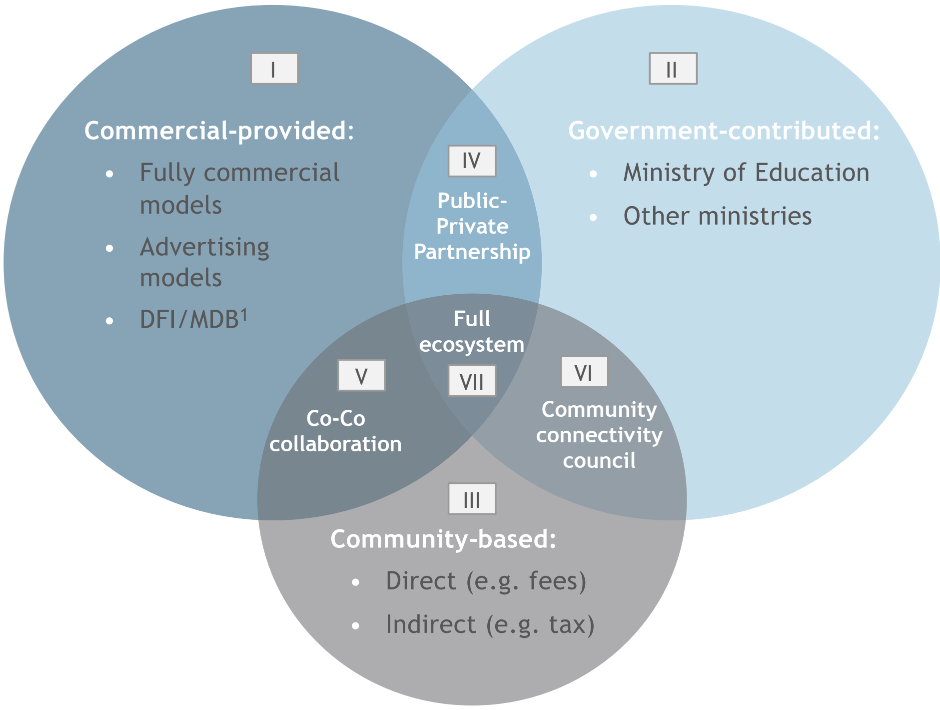
Table 5. Sustainable funding models

Sustainable funding models in developing countries	Model I: Government-contributed	Model II: Commercial-provided	Model III: Community-based
Ongoing and recurring contribution	Often part of budget of ministries, e.g. of education or ICT	Commercial parties pay for opex if income from government contribution or community is large enough to afford the connectivity costs	Cost-sharing by community through payment for use of internet service. Often comes with lower costs due to volunteer-based model
Investments for upfront costs, such as capex	Can take many different forms, e.g. USF funding, spectrum auction prerequisites (implicit contribution), or one-off capex subsidy	Commercial party willing to invest in capex as the prospect for long-term return is positive (often the case in developed regions)	

In order to achieve sustainable funding of school connectivity, a combination of sources is likely required. There is an increasing need to focus on hybrid financing where a wide variety of players have to work together to make funding sustainable in the long run. As such, a blended capital approach could be highly appealing to different providers of capital looking for different risk/ return profiles (with some funders potentially participating in more than one of the layers of capital).

Thinking in archetypes helps in recognizing patterns between regions and can serve as a means for gaining insight into the underlying structures of a region that lead to a particularly suitable funding model.

Figure 15. Country archetypes for funding sources[17,18]



As shown in Figure 15, based on the types of contribution sources that exist, seven archetypes emerge: three primary archetypes (I-III), and four secondary archetypes (IV-VII). Region-specific situations drive the applicability of these contribution archetypes.

- *Archetype 1: Commercial-provided funding*

Generally, regions that fall into this archetype allow for higher potential returns for the commercial parties involved, such as SPs and ISPs. Several underlying drivers are in place that make these regions more attractive to private parties. One of these factors is a higher GDP/GNI per capita, so that the community can directly or indirectly pay for the connectivity. In addition, relative to potential income, the cost of infrastructure rollout would be relatively lower, e.g. because of lower labour costs, a more accessible landscape, and/or a suitable climate that allows for all uses of technology. This way, commercial parties can recoup their costs quicker. The same argumentation holds for opex costs. Finally, more transparent and

17 DFI/MDB stands for Development Finance Institution and Multilateral Development Bank, e.g. the World Bank, African Development Bank, etc.
18 Community-based funding is smaller in size, as it is suitable for ongoing and recurring contributions, but not for upfront capex investments.

stable government policy helps in managing the risk-return profile in line with SP/ISP expectations and reduces the required return thresholds. Next to high potential revenues for commercial parties, it is important that there is a supportive governmental framework in place that allows for commercial involvement without insurmountable or costly entry barriers (e.g. high withholding taxes). Many examples of such approaches exist and can serve as sustainable business models. These include the United Kingdom, France, Italy, South Africa, Germany, and the USA.

> Funding telecommunications infrastructure through private equity or debt is overwhelmingly the most typical case in well-functioning markets. However, where the business cases are built on a narrower basis of profit opportunity, private funding may be problematic. In these cases, the government, and communities, which tend to have different assessments of risk and required return than private investors, may have a role to play.
>
> Source: World Bank (2018)

A wide range of potential private investors can be involved in funding meaningful connectivity. Four categories of private investors can be differentiated:

- **Equity investors:** (Country-related) angel investors, local businesses, local governments, venture capital, infrastructure funds, and crowdfunding.
- **Debt financing:** Local, national, international, and philanthropic banks; innovative financing organizations; and public market bonds (including potentially linking with the further development of local capital markets).
- **Operators and strategic partners:** Mobile network operators; internet service providers (ISPs); fibre network operators (FNOs); tech companies such as Facebook, Google, and Microsoft; other infrastructure owners, such as electricity, road, and water companies; and local entrepreneurial set-up.
- **Development money:** Development finance institutions, multilateral development banks, development venture capital funds, country-related angel investors, and impact funds.

Archetype 2: Government-contributed funding

For governments to be able to participate in the funding of connectivity infrastructure for schools, they need to have reasonable levels of debt and/or be capable of allocating budget on an ongoing basis (contribution) or as a one-off (investment). Oftentimes a high amount of government intervention will be needed if the commercial sector is not able to provide services due to their profit requirements. This often correlates with regions which have relatively lower GDP per capita; a relatively higher cost of infrastructure rollout and/or operational expenditure vis-à-vis potential revenues; and regulatory environments that pose risks or provide barriers to entry or scaling.

A successful example of a government-contributed funding model can be found in certain regions of Australia. The Australian government has set up a programme that provides funds on a competitive basis to carriers to address broadband and mobile telephone black spots and gaps in service provision. The programme is focused on areas where communities benefit most, such as economic centres, emergency service facilities, health clinics, schools, indigenous community centres, and local government sites. The government committed $380 million to the Mobile Black Spot Program for investment in telecommunications infrastructure to improve mobile coverage and competition. This resulted in $836 million in investments through co-contributions from local state territory governments, mobile network operators, and community organizations. It led to the installation of 1,200 new base stations across Australia (Australian Government, 2021).

An important type of government funding that can be sustainable in the long term is USF funding. More research on this can be found here.

- *Archetype 3: Community-based funding*

In this model, both funding and operations are driven by the community.[19] Community-based upfront investments are unlikely given the scale of capex; community contributions are more common. Six factors lead to increased community contributions. First, there must be an expected high demand for internet services, to ensure an incentive for community-based internet connectivity. Second, community-based funding often emerges when there is a lower opportunity for SP/ISP returns, and therefore an absence of existing connectivity providers. Thus community-based networking initiatives are more likely to exist in the absence of alternatives. Third, there should be enough spectrum available, that can be used without a licence. That way, high-quality service, e.g. through Wi-Fi, can be realized. Fourth, the spectrum licensing framework in the respective country has to support community connections. Fifth, local knowledge and the ability to install, maintain and operate networks are required so communities can set up their networks and fix them when needed. Finally, a close-knit community is a positive factor, so that there is an incentive to help each other and an opportunity for leadership. This archetype can often be strong accelerator of demand for internet services. In the long run however, problems with succession and volunteer commitment can be difficult to overcome in this archetype and have to be actively addressed.

Despite their potential for addressing connectivity needs, there are relatively few community networks in developing and developed countries. The primary constraint is the lack of conducive regulatory environments in most countries.

South Africa has successfully set up several community-led initiatives, though most of the country's connectivity is still provided by commercial parties. One example is Zenzeleni Networks, a community-owned wireless internet service provider based in rural South Africa. *Zenzeleni* means 'do it yourself' in Xhosa. Its model aims to significantly cut the costs of telecommunications, retain expenditure within communities as a form of social entrepreneurship, and support the development of a rural digital ecosystem to bridge the digital divide.

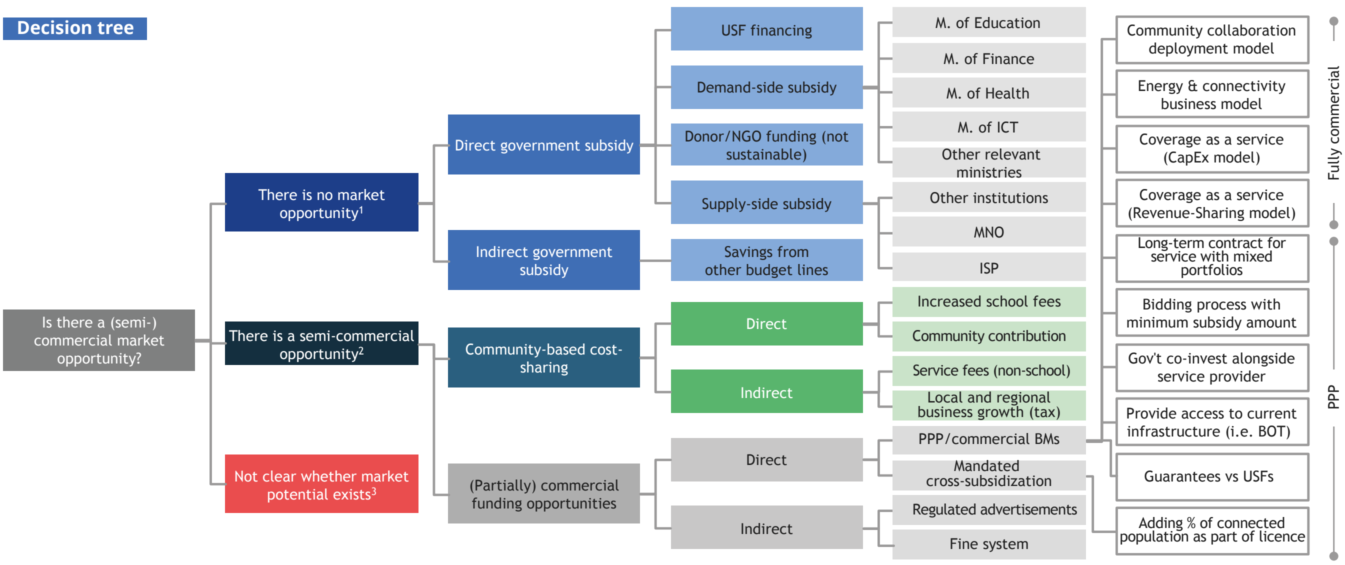
Another successful, large-scale project (in a developed market) is Guifi.net in Spain. This is a free, open, neutral, and mostly wireless community network, with over 35,000 active nodes and about 63,000 km of wireless links. Small community networks can be found in countries like Zambia and Mexico, and even in urban areas such as New York.

19 Note: Community support for the use of the network does not fall under 'community contribution'. In developed nations that are (almost) fully dependent on commercial parties, the community support is to ensure that the commercial model works.

2.5.2 Sustainable funding sources

For each of the archetypes, a combination of funding sources can be used. As the commercial-provided archetype is the starting point to reach sustainable funding, the decision tree in Figure 16 starts with the question: 'Is there an opportunity for companies to be involved on a (semi-) commercial basis?' From that starting point, initial funding ideas can be selected. The remaining gap can then be covered using government funding. In case government funding is not available, or not enough capital can be contributed, this gap can in some cases be bridged by donor funding. In other cases, a staggered rollout can be considered if all economic improvement measures (revenue enhancement, cost reduction, and risk reduction) have been optimized.

Figure 16. Decision tree for funding sources

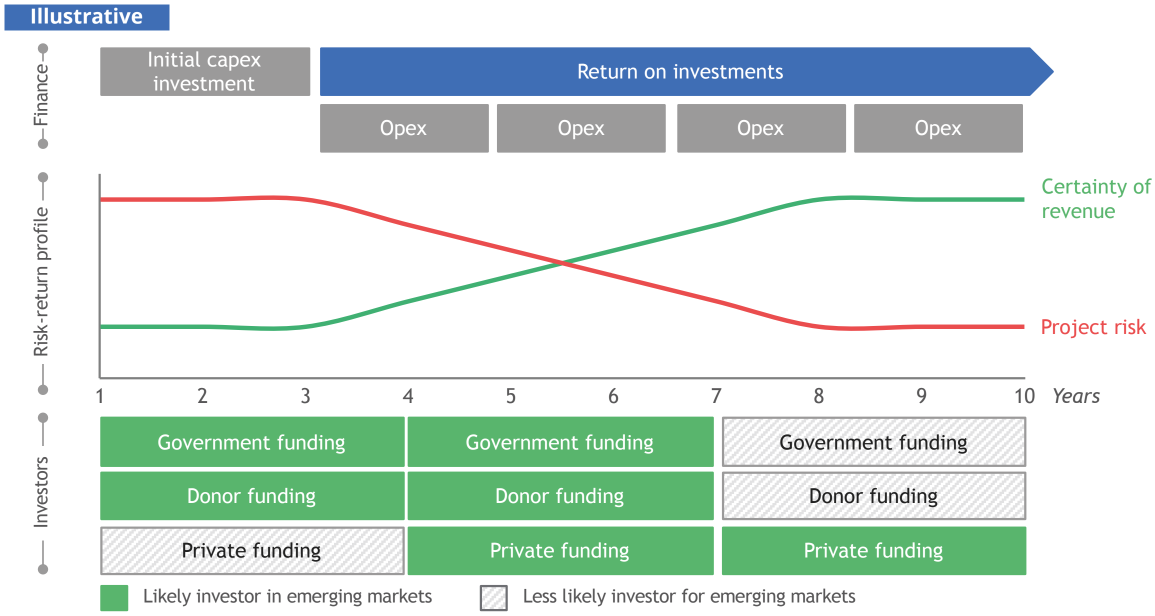


1. Internet access available, but not affordable for school; 2. Internet access available, but only partially affordable for school; 3. No internet access today
Source: Expert interviews, BCG analysis

2.5.3 Evolution of funding sources

The involvement of different funding actors is likely to evolve over time (see Figure 17), with the initial phase being riskier than the operational phase. Some long-time-horizon (commercial) companies could finance the full project duration, e.g. development banks or impact funds, but refinancing after the initial capex phase could be required or desirable in order to adjust the total cost of the project. The roles of the commercial sector, government, and community may change over time. Mechanisms to pay back early investors could also entail longer-term returns once certain threshold returns have been achieved which could provide further, additional incentives for the early funders as well as an attractive profit loop. A likely scenario could be that the government plays a role in the design, construction, and operations until the project risks become lower, transparency becomes higher, and therefore the certainty of revenue becomes clearer. Contrarily however, some commercial parties may be interested in initially building and operating the network, and afterwards transferring it to the government or another commercial party. In this scenario, pre-agreed prices, terms, or other risk-reduction mechanisms would likely be put in place.

Figure 17. Illustrative evolution of risk and return of infrastructure projects



2.5.4 Government actions to enhance funding from the private sector

Local governments can take a wide array of actions to increase the participation of the private sector. Doing so is likely to make funding solutions more sustainable, according to the models used in more developed countries. The government could improve the environment for commercial involvement by focusing on cost containment, revenue enhancement, and risk reduction.

■ *Cost containment*

- **Reduce import tax** for materials and hardware
- Create tax incentives for businesses that thrive on telecoms (e.g. Special Economic Zones)
- Ensure that the **regulatory environment is attractive**, but also provide regulatory support for infrastructure sharing
- **Allow for land appreciation**, so that companies do not have to buy or rent the land
- Reduce spectrum costs in hard-to-connect areas
- Allow for fast approval processes and provide clear communication on timelines
- **Increase access to electricity**, including allowance of off-grid energy solutions
- **Allow for the use of government assets** to roll out infrastructure more cheaply, e.g. right-of-way, electricity poles, existing fibre networks
- Aid in the **reduction** of any other type of **red tape**
- Encourage revenue enhancement
- **Provide or subsidize devices** in otherwise economically unattractive areas and/or remove taxes and fees on devices. Remove barriers to the purchase of important devices
- **Educate communities** on the benefits of connectivity and provide training on how to use it
- **Address safety and security concerns** that communities may have and build consumer trust
- **Accelerate the digitalization** of public services. An example is Irembo in Rwanda,

a government-to-citizen e-service portal that enables the citizen to submit the application and make the payment for various services
- **Create packages for investors** (i.e. provide access to otherwise unattainable investments), such as general infrastructure or energy assets that are state-owned or monopolized
- Allow for the pooling of existing government-owned infrastructure to facilitate steady revenues

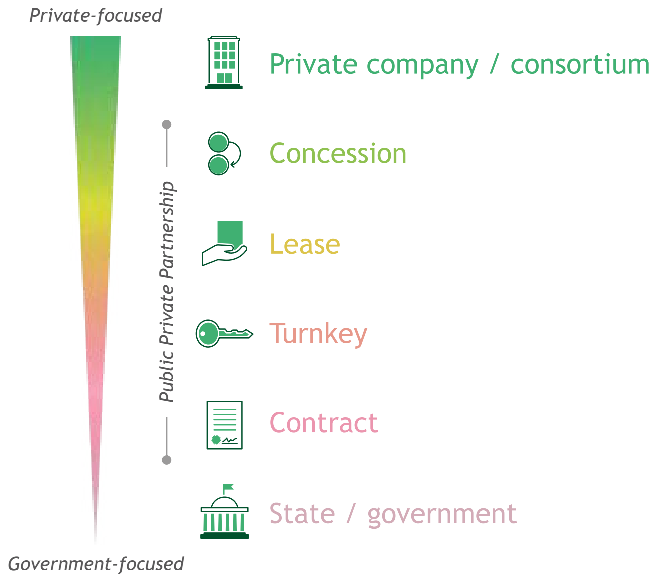
■ *Risk reduction*

- **Provide detailed insight into costs**, including calculations of the capex and opex required and estimates of potential revenues on a per-area basis
- Provide **transparency and certainty** about government policy, regulation, and anticipated or pre-scheduled and disclosed changes and/or reviews
- Provide backstop or first-loss **guarantees**, e.g. against USFs
- Partner with other countries to allow for **risk pooling** to reduce sovereign risk
- Offer government financing for the initial high-risk phase with and provide full **clarity to the private sector before hand-over**
- **Gather granular and trustworthy demand data** related to mobile internet adoption and access as well as connectivity quality
- Set public priorities, targets and budgets based on data-driven assessments
- Provide **dedicated project support** at the highest governmental level and include all relevant ministries

2.5.5 Operating models

A wide variety of management and operational options exist to realize school connectivity (see Figure 18).

Figure 18. Management and operational options

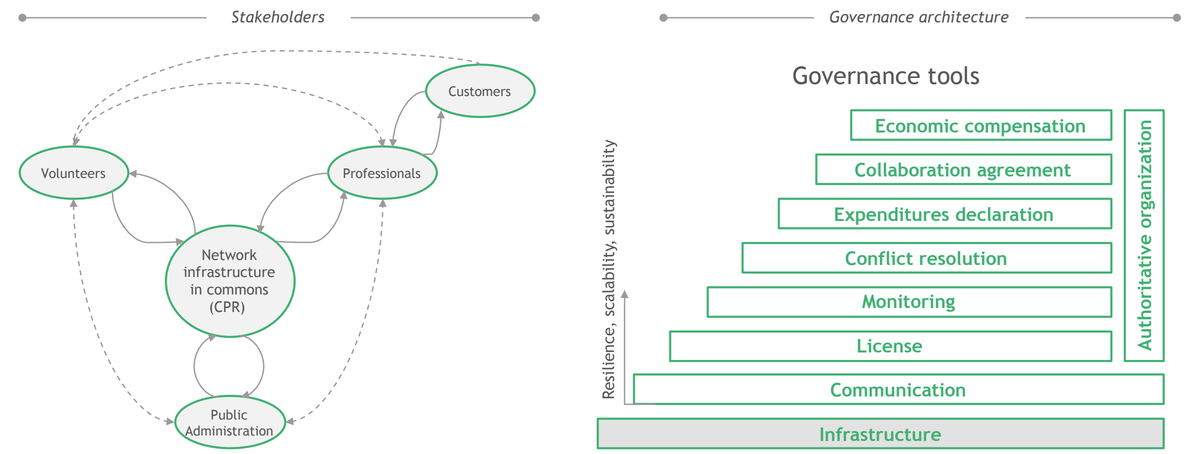


For **archetype I, the commercial-provided archetype**, a private company or a consortium of private companies is responsible for the management and operations. The most straightforward operating approach is a private company or consortium using a Build-Operate-Own (BOO) model, or a Design-Build-Finance-Operate (DBFO) model. For these, all risk, ownership, and responsibility remain with the private sector. This is the set-up generally used by telecommunications firms in developed regions, e.g. in most Western European countries and the United States.

For **archetype II, the government-contributed archetype**, the government, state, or other public entities can be responsible for management and operations. In this model, the government(-entity) can run the management of the infrastructure as a public service. Generally speaking, the public Design-Build-Operate (DBO) model is the most straightforward one. In this model, risk, ownership, and responsibility remain with the public sector. This can be the preferred choice in regions that have monopolistic, state-owned telecommunications companies, or where there is no interest from private parties to participate. Alternatively, the government can consider the concession and contract set-up that are outlined later.

For **archetype III, the community-based archetype**, several models can be used. First, a cooperative can be set up, where the community's people are united. These are controlled and run by their members. Once the community network grows to a substantial size, cooperatives can decide to hire private companies to conduct maintenance and repair. An example is Guifi.net, the Spanish community network. This network has over 35,000 active nodes, and currently employs more than 20 companies that carry out professional activities simultaneously and in coordination with individuals, volunteers, and associations. Even though community networks can be somewhat fragile due to problems with free-riding, succession, and the supply of volunteers, Guifi.net has set up a clear stakeholder and governance architecture (see Figure 19) to provide ways to address these challenges.

Figure 19. Stakeholders and governance architecture



Source: Baig et al. (2015)[20]

An alternative to a cooperative is a set of volunteers who have a high level of community participation and commitment to keeping the network viable. This voluntary model is however less scalable and less sustainable in the long run. Nevertheless, it can serve as an important kick-starter to community connectivity.

For community networks, the fundamental question is how the infrastructure is conceived. In this regard, expert distinguish between two main groups:

- **Open to participation:** In this set-up, everybody can participate, including governments, private investors, for-profit investors and other companies. One of Guifi.net's major contributions to community networks is having shown the possibility of building and operating a network infrastructure that is conceived as an open Common Pool Resource with the participation of for-profit companies and

20 Even though the source is outdated (2015), the writers of this chapter have been in direct contact with authors Roger Baig and Ramon Roca to verify its accuracy.

governments in addition to volunteers and beneficiaries.[21]

- **Closed networks:** These are limited to a specific set of participants, e.g. private investors only.

When it comes to addressing the connectivity gap, equity and inclusion are imperative, so community networks can be especially relevant in areas that are not served by commercial companies, or charge prices that are not accessible to all. Zenzeleni Networks offers prices with different rates depending on speed and GB. In addition, they work with several 'anchor clients', e.g. hospitals, NGOs, local businesses, and homes, to ensure steady revenue streams to safeguard the existence of the network. For households with fewer reserves and less reliable income streams, the internet is offered through public Wi-Fi hotspots which offer quality connectivity with costs that are 20 times lower than those of other operators.[22]

For archetype IV-VI, the 'PPP', the 'Co-Co collaboration', the 'Community Connectivity Council' and the 'Full Ecosystem', several options exist. These are a concession, lease, turnkey or contract (see Figure 20).

Figure 20. Management and operational models.

Model	Main variants	Ownership of capital assets	Responsibility of investment	Assumption of risk	Duration of contract
Private company or consortium	• Build-Operate-Own (BOO) • Design-Build-Finance-Operate (DBFO)	Private	Private	Private	Indefinite
Concession[1]	• Franchise • Build-Operate-Transfer (BOT)	Private/public	Private/public	Private/public	3-7 years
Lease[1]	• Build-Lease-Transfer (BLT) • Lease	Public	Public	Private/public	3-20 years
Turnkey[1]	• Turnkey	Public	Private/public	Private/public	1-3 years
Contract[1]	• Outsourcing • Maintenance/operational management	Public	Public	Private/public	1-5 years
State/government	• Public Design-Build Operate (DBO)	Public	Public	Public	Indefinite

Public · Private · *Private/public*

1. Can also be between two private parties, however, focus here is on PPP; Source: World Bank, Investopedia, UNESCAP, expert interviews, BCG analysis

A concession could be considered by the government if they are the owner of the connectivity infrastructure, but do not want to bear the full investment responsibility and associated operational risks. The government may use a concession if there is a lot of potential for efficiency gains by outsourcing partial ownership and operations to a more suitable private party. This model is less feasible if the government wants to keep a high degree of control.

- The advantage of a concession model is that the private sector tends to operate and manage commercial networks better vis-à-vis government (entities). In addition, the public sector shifts a significant amount of risk to the private sector using this method. Finally, this model allows for flexibility of the counterpart in case of disappointing results in terms of services delivered.

21 Based on interviews with Roger Baig and Ramon Roca from Guifi.net

22 Based on an interview with Sol Luca de Tena, Acting Chief Executive Officer at Zenzeleni Networks

- The disadvantages of a concession model include that negotiations between parties can take a long time. Also, contingent liabilities to the government remain, and concessions can be complex to implement, administer and monitor.

A lease can be combined with other arrangements, for example turnkey. The government could consider using a turnkey contract in combination with a lease to ensure that each part of the process is optimized. This type of contract may be chosen if the government wants to retain ownership of the connectivity infrastructure but does not have the right capabilities or the desire to operate the infrastructure.

- The advantages of a lease are that it can be implemented relatively quickly. In addition, significant private sector investments are possible under longer-term agreements, varying from three to 30 years in general.

- The disadvantages are that there is little incentive for the private sector to invest, and the risks remain with the public sector. For this model to work, the government has to build infrastructure or have it in place already. Finally, regulatory oversight is required when using a lease.

Turnkey is a traditional public sector procurement model for telecommunications projects and may be used if the government does not have the right capabilities to effectively and efficiently build the connectivity infrastructure, but does want to keep ownership and operational control.

- The advantages of turnkey are that this method can optimize the expertise of the counterpart. Having telecommunications infrastructure built by third parties in areas that are usually hard to supply for larger SP companies or governments, allows for a low-cost and efficient roll-out method. In addition, the contract agreement is generally not complex and can be negotiated relatively quickly. In line with this, contract enforcement is clearer and easier.

- The disadvantage of turnkey solutions is that there is no strong incentive for the third party to be bullish on completion time. Moreover, the risk remains with the public sector or the private buyer, even after the construction phase. Finally, for operation, the right capabilities need to be contracted, or build inside the buyer.

In a contract, the government retains all ownership, yet can bring in expertise from the private sector. This model can typically be used in regions where it is politically or socially more acceptable for the government to take the lead.

- The advantages of a contract are that implementation can be relatively fast. It is the least complex method in the PPP category. Additionally, the government can ensure the quality of the telecommunications infrastructure using a contract.

- On the flipside, efficiency gains may be limited with little incentive for private parties to invest. Furthermore, annual costs for the government may be relatively high, due to the shorter time frames often being used. Other disadvantages are that the government has to build the infrastructure or have it in place already, and all of the risks remain with the public sector.

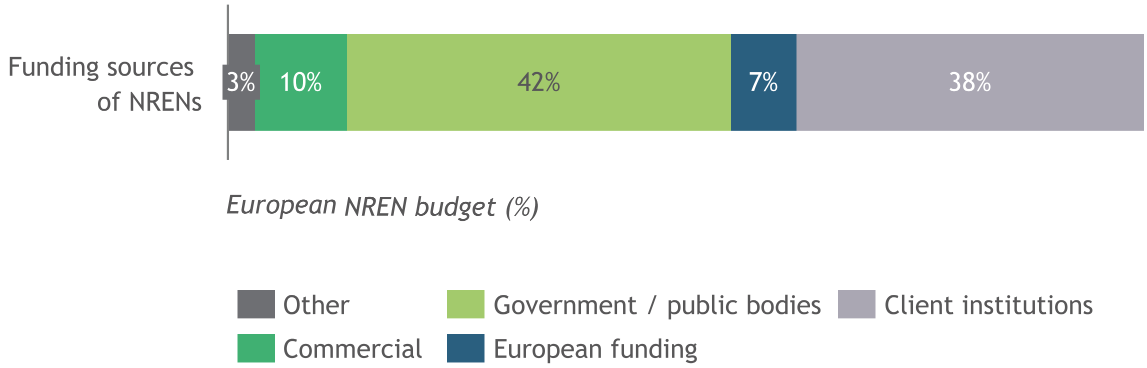
PPP models can typically be structured via a Special Purpose Vehicle (SPV) or Joint Venture (JV).

■ *NRENs*

A special type of operational model to be considered is a National Research and Education Network (NREN). NREN organizations are specialized internet service providers dedicated to supporting the needs of the research and education communities within their own country.[23] According to Geant (2020), 'the primary focus of NRENs is to provide universities and research institutes with high-quality network connectivity and related services by connecting campuses and institutions to each other, and to the rest of the internet'. NRENs are often founded and financed by universities, research institutions, or government ministries (see Figure 21).

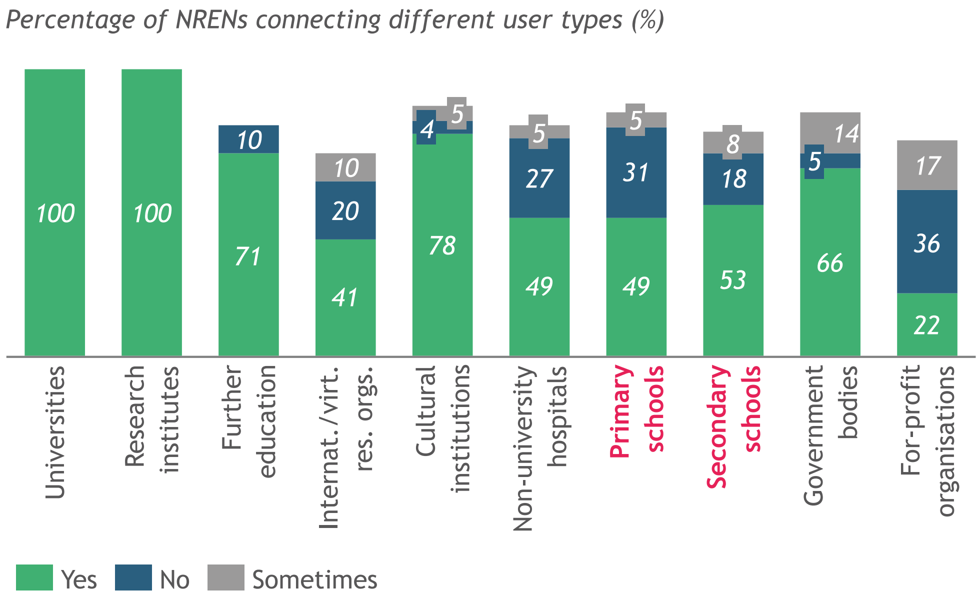
23 Geant (2020)

Figure 21. Funding sources of EU-based NRENs



Although NRENs initially focused predominantly on universities and research institutions (and all EU-based NRENs still do), an increasing number of NRENs have been focusing on primary and secondary schools, thereby providing a potentially interesting operational method in some countries (see Figure 22).

Figure 22. Percentage of EU-based NRENs connecting different user types



Besides being an operating model, NRENs can serve as important enablers and/or partners in rolling out school connectivity, due to their experience, expertise, existing backhaul and reputation.

2.5.6 Case studies

- *Rwanda*

Background and current connectivity

- About seven out of ten people in Rwanda have access to the internet. Even though usage is low, coverage is quite high: ~98 per cent of the nation is covered by 4G.
- In Rwanda, 35 per cent of primary schools, and 61 per cent of secondary schools are connected to the internet. Despite a close to 100 per cent coverage level, schools that are not connected do not have internet access for several reasons:
  - Lack of electricity
  - Lack of affordability
  - Lack of digital literacy
- Improving infrastructure is nevertheless key in Rwanda. Affordability can be improved by adding cheaper alternatives to the existing 4G coverage. In addition, the lack of electricity can be tackled concurrently with an increase in fibre backhaul, which is most suitable for schools, or the installation of solar panels alongside the connectivity.

Funding required for infrastructure

- Given the broad 4G coverage in Rwanda, the cost breakdown has been estimated using the following technologies:[24]
  - Fibre: 50 per cent
  - WISP: 47 per cent
  - 4G: 2 per cent
- An increase of ~$8 per student is required to fund school connectivity (excl. overhead costs). Even though fibre is expensive, larger school sizes usually means fewer schools and therefore lower costs vis-à-vis other countries.
- This means average annualized costs of $5,500 per school and $9.1 million for the whole country (excl. overhead costs). These costs exclude the expense of adding a grid network or decentral electricity, which is required for many regions in Rwanda.

Funding models considered

- **Government increases school funding:** The government decides to pay for all schools to be connected, either through demand- or supply-side subsidies. This model could be relevant as Rwanda's government expenditure per student as a percentage of GDP is the second lowest among the six focus countries. It is imperative however for different ministries to work together to spend sustainably.
- **Community pays for connectivity:** Most costs are covered through a community contribution, where the school serves as a hub for community connection. A government subsidy would be used to bridge the remaining gap.
- **Electricity as a business model:** This combines revenues from electricity, together with community contributions.
- **Tax-revenue-linked financing:** Investors provide upfront financing in return

24 Given the fact that RFPs would be sent out in a technology-agnostic way, the actual technology breakdown may be different in practice. This breakdown has been assumed, however, to include the total cost of connecting schools.

for longer-term repayment out of tax revenues. A portion of the increased tax revenue as a percentage of GDP is passed back to investors for a set period.

- *Brazil*

Context and current connectivity

- Brazil is a sizeable and relevant market, with large differences between regions in terms of economic well-being.
- The school system looks very different per region with far reaching effects on quality outcomes.
- In terms of costing, though the price of a data basket of 1.5GB is below the ITU's suggested affordability level, due to extreme inequality, it is still too expensive for many, especially in poorer socio-demographic areas such as the north and northeast.
- Therefore, a regional focus is required in determining what sustainable business models to use in rolling out school connectivity.
- Differences in socio-economic indicators also have an effect on school connectivity, with the majority of unconnected schools in the north and northeast.

Funding required for infrastructure

- Given the geographical challenges in Brazil, it is not possible economically to cover the entire country in fibre. A breakdown for the country could look as follows (but RFPs should be sent out in a technology-agnostic way):
  - Fibre: 10 per cent
  - LTE: 12 per cent
  - Wisp: 72 per cent
  - Satellite: 6 per cent
- In terms of financing, an additional average of $34 per year per student would be required to connect the remaining 23 per cent of schools. This is excluding overhead costs or any upgrades necessary for already-connected schools.
- The average school size in Brazil is relatively large (306 students), which would lead to a low cost per student; however, the size of unconnected schools is significantly lower (116 students).
- This would work out to an average annualized cost of $3,925 for each school (excl. overhead costs).

Funding models considered

- **One-off subsidy by the government:** This can come from many different government sources, such as: 5G spectrum auction (indirect funding); fine system; USF financing; and tax exemptions/discounts for SPs.
- **Advertisement model:** Students are shown a maximum number of vetted ads per day in return for payment by commercial parties (to help offset operating expenses or generate revenue).
- **Open access network operator:** Infrastructure is provided by one of the large telecommunications companies and subsequently operated for a revenue-sharing fee by smaller ISPs.
- **Government increases school funding:** The government pays for all schools to be connected, through a demand- or supply-side subsidy.

A suggested roadmap for rolling out school connectivity in a country is the following iterative five-step process with frequent government touchpoints (see also Figure 23).

1. **Framing the initiative**

The first step is to focus on target setting, including determining how many schools the project intends to connect. Agreeing on the vision of the project and the intended strategy to reach school connectivity is also important. In addition, determining what legislative or policy boundaries are in place is crucial during the initial framing phase. For example, if a USF funding model is not available, this cannot be considered as an option in further stages.

After determining the project's framework, the government's wants, needs, and potential contributions should be aligned to make sure boundaries are set correctly and goals accord with government policies.

2. **Technology**

It is imperative to start with an end-goal in mind, such as the connection of a certain number of schools in a set region. Additionally, it is vital to specify the minimum internet speed for meaningful school connectivity, preferably in close collaboration with the local government. Climate, existing backhaul, topography, and remoteness need to be taken into consideration in determining what mix of technology is most economically and practically feasible. It is highly recommended to send out RFPs to commercial parties in a technology-agnostic manner, however, describing what functionalities are required to allow for the optimization of expertise. In addition, it is important to make sure that the bandwidth and other characteristics of the network can be upgraded in the future, as technology develops quickly and (education) software will increasingly need better performance capabilities.

3. **Financing**

Based on the internet speed and other goals set, a cost analysis can be done and converted into expected upfront investment needs, as well as ongoing operational expenses. As a result, the required level of annualized revenues can be estimated to ensure that the financing covers the costs. This can also serve as an input for the funding assessment.

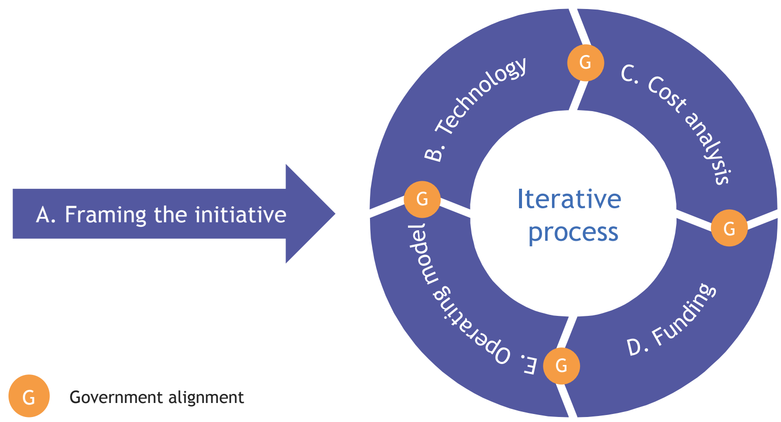
4. **Funding methods**

The next step is to determine what archetype the specific country would fall under. This can be analysed by studying its macro data, SP landscape, and legislative set-up. Once the right archetype has been chosen, the decision tree shown in Figure 16 can be used to assess what specific source of funding fits within the relevant archetype. Each funding model encompasses different investment and contribution cash flows which have to be considered together with the costing model. Practical implications (such as payment methods in the case of community contributions) which may arise from choosing a specific funding type need to be taken into account.

5. **Determining what operating model to use**

Country-specific situations, combined with the chosen archetype, lead to an optimal operating model. The terms and conditions of the model need to be reviewed and assessed, especially when working together with commercial parties, to ensure the needs of the students are prioritized.

Figure 23. Iterative roadmap for school connectivity



2.6 Conclusion

Governments and education stakeholders should consider strategies across four areas. The first is to facilitate the transition toward digital societies, in three steps including (1) assessing digital maturity; (2) identifying and assessing digital skills through dedicated frameworks; and (3) investing in human capital through digital skills policies. A second strategy is to overcome the digital divide, which is manifested in infrastructure and access to the internet, and devices and coverage. A third strategy is the digital transformation of education and training systems including the following steps: (1) reviewing existing levels of digital integration; (2) investing in infrastructure development; (3) making schools ready in terms of infrastructure and connectivity; (4) updating curricula and content; (5) improving learners' and households' readiness; (6) assessing teachers' readiness for their new roles; (7) providing support and training to teachers; (8) strengthening school leadership; and (9) setting up system-level interventions. Ensuring sustainable funding is the fourth enabling strategy and should based on the following principles: placing learners and educators at the centre, prioritizing equity and inclusion, focusing on meaningful connectivity, and integrating hybrid learning objectives with national and international education goals.

The costs of hybrid learning are driven by telecommunications infrastructure, the regulatory environment, digital skills training, professional development for the education workforce, learning devices, classroom equipment, curriculum alignment, digital content, OER platforms, school infrastructure, and other recurring expenses such as electricity or maintenance. Investment in infrastructure can be secured through commercial models, community cost-sharing models, or community networks. ICT devices can be financed through government purchase, leasing, and/or cooperative purchasing. Digital skills development usually depends on government funds, development aid, multilateral banks and innovative financing mechanisms. New funding arrangements are emerging that support access to digital content for hybrid learning, including the collaboration and engagement of communities, state and non-state stakeholders, institutions, and international donors.

3

Framing the Future Developments

Chapter 3: Framing the Future Developments

In the overall context of network expansion and connectivity, various technologies (wireless, wired, and satellite) can complement each other to address the needs, demands, constraints, and use cases for which each technology and service may be the best fit. Following on from the previous chapter's focus on four key enabling areas for hybrid learning – facilitating the transition towards digital societies, overcoming the digital divide, digitally transforming education and training systems, and establishing sustainable funding models – it would be remiss not to briefly consider emerging developments in frontier technologies, which can be used in conjunction with existing solutions, and which are likely to have subsequent implications for all four. This chapter briefly considers what frontier technologies are, why they are important, and what their implications might be for future hybrid learning possibilities. Brief case studies, highlighting how these technologies are currently being used, are provided as a reference point (with additional cases and examples available in the Compendium). The chapter concludes by presenting three different scenarios for the future of frontier-technology-enabled hybrid learning.

3.1 Frontier technologies: What are they and why are they relevant?

While *frontier technologies* may have varying definitions, we consider its broader sense for the purposes of this analysis. Frontier technologies are tools at the intersection of progressive and radical thinking, with a potential to address global challenges through their deployment in real scenarios.

Frontier technologies provide alternatives to reshape, further develop, and reorganize future economies, societies and education systems. Current examples include AI, machine and deep learning, big data and data analytics, 5G, Wi-Fi 6, blockchain and distributed ledgers, and cloud-to-edge technologies, as well as a host of other interrelated developments in augmented and virtual reality, haptic learning, smart materials, and so forth. Each will undoubtedly open new possibilities for various contexts and sectors across the educational ecosystem, while their combination will further multiply alternatives for transformation.

Below, we briefly focus on the main characteristics of four interdependent technologies deemed likely to have a great impact on our current information society, infrastructure, and future hybrid educational possibilities, namely 5G, AI, blockchain and digital ledgers, and cloud-to-edge internet architectures. Our intention is not to provide a full, detailed review but rather to summarize the central features of each and highlight its potential for hybrid learning experiences.

3.2 5G (Fifth generation cellular networks)

3.2.1 Overview of key features

Whilst 5G developments have a range of key features and implications (see Table 6), the main ones to consider are the capacity for increasing data traffic and speed, in comparison to existing connectivity possibilities, and through that, being an enabler of more sophisticated and data-intensive digital learning tools.

Table 6. Overview of key features: 5G

- A more powerful technological development with a fast bit-rate, offering higher bandwidth, and utilization of wireless networks to function effectively and create new possibilities
- Enables higher data speeds, higher volumes of traffic, greater reliability, lower latency and shorter communication delays, with lower (*zero*) downtime
- Increased gigabit browsing speeds will potentially make mobile internet speeds equivalent, if not superior, to hard-wired fibre connections
- Potential for reorganizing information and data flows and the processing architecture of the internet, fusing telecommunications with computer networks
- Can support the move of data processing from large cloud server 'farms' closer to the end-users
- Requires educational institutions to be able to connect to a nearby antenna and local Wi-Fi networks. Local RAN can be connected to the internet either using a fibre-optic line or through a radio link

3.2.2 Potential benefits for hybrid learning

Table 7 gives an overview of the potential benefits of 5G for (hybrid) learning, with greater connectivity allowing new content and experiences to be effectively incorporated, as well as enabling new synchronous and asynchronous hybrid configurations with both homogenous and heterogeneous learner groups.

Table 7. 5G: Potential benefits for (hybrid) learning

- Greater bandwidth provides greater stability and speeds enabling a larger number of students to learn online, using multiple devices and wider ranges of varied applications
- Offers potential for learners to use multiple devices and applications and tackle different learning tasks at the same time (and in diverse locations), with more opportunities for differentiating and personalizing hybrid learning experiences
- Lower latency facilitates better real-time communication, collaboration and knowledge exchange opportunities between learners and educators in different locations
- Faster mobile internet speeds can support greater and more effective experiential, located, remote, and problem- and project-based learning in the field, including 'in-situ' and 'on-the-job' learning, helping us reconsider how and where learning can occur as part of a hybrid ecosystem
- Supports the use of more data-intensive and remote-processing learning, such as AI, augmented reality and virtual learning. These and other tools can add additional immersive, dynamic and interactive dimensions to hybrid learning
- Opens up possibilities for piloting innovative pedagogical approaches and learning experiences that require higher data traffic and remote processing
- Greater speed and information exchange can enable quicker and more targeted feedback and assessment, both in class and remotely, through direct learner-educator interaction and via intelligent, automated assessment tools
- Offers potential for more seamless learning and teaching, not just in terms of start-up, continuity of connection, and instant downloads, but also through the ability to automatically log in from any location and receive faster, automated feedback on learning and performance
- Enables more effective use of big data and data transfers between networks and systems to support tailored feedback and pathways for learners

5G has the potential to revolutionize connectivity performance. In so doing, it can enable the development of new, immersive, dynamic, diverse and interconnected hybrid opportunities for a greater number of learners. While it is set to be incorporated into some education systems, its precise and full educational utility is still emerging, and this will evolve further as other related technological developments unfold.

3.2.3 Barriers to implementation

There are ongoing financial, logistical and technical challenges that need addressing, both at global and national levels, before wider rollout is achieved and possibilities are embedded fully within education systems (see Table 8). Moreover, technological developments are not self-determining, and if the aim is to increase educational opportunities for all, then global and national strategies for rollout might firstly need to be targeted at those who have fewer opportunities to learn, digitally or otherwise.

Table 8. Barriers to implementation

- Cost: infrastructure, implementation, maintenance, updates, and network integration costs can be higher than traditional networks
- Increased ability to share information over networks brings additional data security and safety risks
- Network and system compatibility challenges
- Requires 5G-capable devices to ensure fullest benefits

Box 24 illustrates the impact that 5G is already having in terms of providing sufficient connectivity to enable remote learning.

Box 24. Mobile internet

Ericsson worked with Vermont Telephone (VTel) to bring mobile internet to high school students in Rutland, United States, a city where many families lack sufficient broadband connectivity for remote learning. Ericsson expedited the installation of next-generation 4G/5G wireless radios and antennas on a building in downtown Rutland. VTel delivered wireless modems and routers to homes, allowing students to receive free internet service immediately. It all happened in less than 10 days, helping local students get the most out of remote learning.

3.3 Artificial intelligence (AI)

3.3.1 Overview of key features

AI[25] combines computer science and robust data sets to enable problem-solving (and problem-setting), often performing tasks that typically require time and resources. AI, and other interrelated developments, are potentially key enablers of innovation across a range of fields and sectors, including education. AI developments have been incorporated into education for a number of years; however, the COVID-19 pandemic and the increased emphasis on virtual and distance learning have also resulted in greater interest in harnessing its potential to enhance hybrid learning opportunities.

Amongst the many affordances of AI, two key elements worthy of particular consideration in relation to hybrid learning are: the potential of AI to provide a more diverse range of learning

25 UNESCO's World Commission on the Ethics of Scientific Knowledge and Technology (COMEST, 2019) describe artificial intelligence as 'machines capable of imitating certain functionalities of human intelligence, including such features as perception, learning, reasoning, problem solving, language interaction, and even producing creative work'.

experiences that are autonomous (important for those who cannot access institutions or educators) and facilitated (valuable for diversification of learning activities); and the potential of machine learning to intelligently respond to students' learning objectives and needs through customization.

3.3.2 Four categories of AI

Whilst there are many forms of AI, and many different ways of categorising it, a report by PricewaterhouseCoopers (Rao and Verweij, 2017), presents a useful model for understanding the four main types of AI and their potential applications to hybrid learning.

Two focus on machine-driven processes (AI):

- **Automation:** systems that assist the automation of existing manual and cognitive tasks but do not adapt (hardwired).

- **Autonomous intelligence:** systems that can adapt to different situations without human assistance (adaptive).

The other two focus on interactions between humans and artificial intelligence (H+AI):

- **Assisted intelligence:** systems that help humans make decisions and take actions but do not learn from interactions (hardwired).

- **Augmented intelligence:** systems that augment human decision-making and continuously learn from their interactions with humans and the environment (adaptive).

3.3.3 Potential benefits for hybrid learning

UNESCO developed a comprehensive analysis and framework regarding the integration of AI in education. The Beijing Consensus on AI and Education is a landmark in this context as the first-ever document to offer guidance and recommendations on how best to harness AI technologies for achieving the Education 2030 Agenda. It was adopted during the International Conference on Artificial Intelligence and Education, held in Beijing from 16 to 18 May 2019, by over 50 government ministers, international representatives from over 105 Member States, and almost 100 representatives from UN agencies, academic institutions, civil society and the private sector. The Beijing Consensus comes after the Qingdao Declaration of 2015, in which UNESCO Member States committed to efficiently exploiting emerging technologies for the achievement of SDG 4.

The Consensus affirms that the deployment of AI technologies in education should be purposed to enhance human capacities and protect human rights for effective human-machine collaboration in life, learning and work, and for sustainable development. The Consensus states that the systematic integration of AI in education has the potential to address some of the biggest challenges in education, innovate teaching and learning practices, improve accessibility and ultimately accelerate the progress towards SDG 4. In summary, the Beijing Consensus recommends that governments and other stakeholders in UNESCO's Member States:

- Plan AI-in-education policies in response to the opportunities and challenges that AI technologies bring, from a whole-government, multi-stakeholder, and inter-sectoral approach, that also allow for setting up local strategic priorities to achieve SDG 4 targets;

- Support the development of new models enabled by AI technologies for delivering education and training where the benefits clearly outweigh the risks, and use AI tools to offer lifelong learning systems which enable personalized learning anytime, anywhere, for anyone;

- Consider the use of relevant data where appropriate to drive the development of evidence-based policy planning;

- Ensure AI technologies are used to empower teachers rather than replace them, and develop appropriate capacity-building programmes for teachers to work alongside AI systems;

- Prepare the next generation of the workforce with the values and skills for life and work that are most relevant in the AI era; and

- Promote equitable and inclusive use of AI irrespective of disability, social or economic status, ethnic or cultural background, or geographical location, with a strong emphasis on gender equality, as well as ensuring ethical, transparent and auditable uses of educational data.

Table 9, adapted from Holmes et al. (2019), identifies some of the different ways AI can be incorporated into education to: teach students; support students; support teaching; and support systems.

Table 9. Applications of AI in education

Teaching students	Supporting students	Supporting educators	Supporting systems
• Intelligent tutoring systems (ITS), including automatic question generation and tests • Automated summative grading • Dialogue-based tutoring systems • Language learning applications, including pronunciation detection • Simulations and information visualizations	• Exploratory learning environments • Formative writing evaluation • Learning network orchestrators • Language learning applications • AI collaborative learning • AI continuous assessment • AI learning companions • Course recommendations	• ITS + learning analytics • Summative writing evaluation and essay scoring • Student forum monitoring • AI teaching assistants • Automatic test scoring • OER content recommendations • Plagiarism detection • Student attention and emotion detection	• Education mining for resource allocation • Diagnostics for learning difficulties (e.g. dyslexia) • Synthetic teachers • AI as a learning research tool

Teaching students	Supporting students	Supporting educators	Supporting systems
	• Self-reflection support, including learning analytics and meta-cognitive dashboards • Learning by teaching chat-bots • Sophisticated formative assessment and feedback • Use of AI and data-driven functionality through search engines, reference systems, social media, mobile phone cameras, video meetings, and games • Automatic translation and video captioning • Simulations and immersive learning environments responding to learner inputs	• Translation and video captioning, supporting accessibility and the use of a larger number of learning resources • Customized digital lessons and resource recommendations generated by AI • Information visualizations to enhance content that can be tailored to individual learner/group needs • Accessible materials for learners with special needs	

3.3.4 Barriers to implementation

Whilst AI undoubtedly has many potential applications that can enhance hybrid learning models, there are a number of concerns about its design, use and implementation. As most AI applications in education require reliable and robust data sets, there are concerns about data availability as well as significant data security, safety, tracing and other ethical concerns, especially when data are shared across networks and systems. Many contexts do not have the necessary processing, connectivity or infrastructure requirements to effectively incorporate the most dynamic and interactive elements into learning experiences.

There are also concerns that while AI has the potential to create innovative learning experiences, developments are seldom supported by a clear pedagogical framework. Moreover, there are concerns that most applications in formal education systems will focus more on improving monitoring, measuring and assessment rather than creating new and immersive learning possibilities. It is also necessary to consider that algorithms are not free from biases[26] and these need to be properly assessed and addressed to include diverse and gender-balanced inputs for its development to avoid deepening the disparities in education.

Box 25 illustrates how developments in AI can help personalize learning plans and reduce workloads for educators.

26 Some of the most heavily-studied categories of biases are on race/ethnicity, gender and nationality (Baker and Hawn, 2021)

Box 25. Century Tech

The Century Tech platform utilizes cognitive neuroscience and data analytics to create personalized learning plans and reduce workloads for instructors. The AI platform tracks student progress, identifies knowledge gaps and offers personal study recommendations and feedback. Century Tech also gives teachers access to resources and decreases the amount of time they have to spend on planning, grading and managing homework.

3.4 Blockchain and distributed ledger technologies

3.4.1 Overview of key features

Blockchains and distributed ledgers are potentially disruptive technologies for education (Sharples and Domingue, 2016). Nevertheless, its incorporation in education is still in its relative infancy, perhaps because the concept is both alien to many, and viewed cautiously by others. However, among the values of blockchain in education, are that it ensures a reliable, secure and transparent historical ledger for verifying all academic credentials and qualifications. Once information is submitted to the ledger, it is difficult to change, thus reducing the likelihood of manipulation and fraud.

Digital ledger technologies (DLT) are essentially decentralized databases managed by multiple participants within different nodes across a network of trust. Some DLTs are open, so that anyone can participate in running the network, and there is no control point in the system. Others are permissioned DLTs, where the network nodes are run by selected parties. Access to the ledgers can also be restricted to selected participants, or made publicly available to anyone on the internet. Ledgers are copied across all computers that participate in the network trust process. The ledgers can be inspected by anyone and the use of public key encryption guarantees that the transaction records cannot be forged.

3.4.2 Potential benefits for hybrid learning

The benefits of DLTs in education are that they address three main challenges: (1) the need to have credible and portable evidence of educational achievement, so that the quality of the education provider is verified and the certificates themselves are tamper-proof; (2) the need to securely automate processes and significantly reduce the very large effort and cost of undertaking such verification, in particular across educational institutions, providers, and national boundaries; and (3) the need to offer new, flexible and iterative possibilities for the accreditation of micro-learning (and associated micro-credentials), which may have particular value in skills- and competency-based approaches.

Table 10. Blockchain: Potential benefits for (hybrid) learning

- Can transform record-keeping of certificates and credentials, which is very useful in emergencies (e.g. UNESCO is exploring blockchain on its Qualifications Passport that would allow refugees to have their qualifications recognized around the world)
- Reduces the need for third-party verification checks of qualification authenticity (for both students and potential new employees), identifying and reducing fraudulent qualifications and applications
- Can reduce the likelihood of data manipulation by individuals and also deletion by hackers
- Can decentralize online learning by providing recognition to only those institutions that provide quality provision and are in networks of trust
- Provides new opportunities for micro-learning, micro-credentials and continuous formative assessment, and has significant potential to support competency-based learning and accreditation across all educational sectors, particularly in the skills, work-based and lifelong learning domains
- Robust and trustworthy micro-credential systems can help reorganize education away from high-stakes end-point assessments and examinations
- Can provide new ways of ensuring digital rights protection that can facilitate (open) sharing of educational content

The main value of blockchain for hybrid models will likely be perceived in terms of its potential to address the growing need to assure consistency and verification processes and avoid fraudulent manipulation, especially given the varied contexts, locations, partners and awarding bodies involved in the global hybrid ecosystem. However, it is also a means of providing credible, alternative, and flexible routes for learning and accreditation that could help unshackle education systems from the preoccupation with, and organisation around, monolithic 'end-point' assessments and examinations. Micro-learning and micro-credentials have great potential, especially in the skills, work-based and lifelong learning domains, but also in other competency-based approaches.

Because of such possibilities, there is an opportunity to explore new potential pedagogical and learning practices (especially in relation to micro-learning and micro-credentials) that could be applied in hybrid learning environments.

As more opportunities to learn and gain qualifications through a range of geographically dispersed and diverse provider types arise, blockchain can also become an effective tool to help ensure more consistency of quality. From a learner's point of view, there is a need to consider how to avoid enrolling in poor-quality courses or those attached to what are perceived as low-status awards. If applied carefully, blockchain could also help tackle the growing instances of providers who develop rigid, 'one-size-fits-all' offerings with little or no student feedback or input from educators to guide them.

Public DLTs will also make it possible for the learners to manage their individual learning histories. This offers greater security and integrity, and is likely to become more important as the number of providers and routes for learning and accreditation expands.

DLTs can also provide a means of protecting copyright and digital rights, enabling content creators to store information in a secure and encrypted chain, accessible only by permitted users, and allowing them to track, verify and permit access to and use of their content.

To protect privacy, verifiable credentials can be implemented with 'zero-knowledge proofs' that only assert specific attributes of the certificate, or propositions derived from it. A user can, for example, give a potential employer the right to check the completion of a specific training course, without having to reveal further information.

Whilst there are many possibilities that may arise as a result of the incorporation of blockchain in the field of education, several examples already exist that provide tangible insights, such as those briefly outlined in Table 11.

Table 11. Blockchain in practice

Odem
Odem connects students, educators and professionals to appropriate and trusted courses and resources, using smart contacts. The Odem ledger recognizes courses and skills, and offers 'skills badges' for both students and educators to demonstrate their competencies.
Blockcerts
One of the early educational uses of blockchain was the Blockcerts platform developed by Learning Machine (Hyland Credentials) and the MIT Media Lab. Blockcerts is an open-ended platform for creating, issuing and verifying educational certificates. Grades, transcripts and diplomas can be stored for immutable insight into past academic history.
Gilgamesh Platform
The Gilgamesh Platform is a knowledge-sharing social media platform powered by Ethereum smart contracts and blockchain technology. It lets its community communicate and connect with one another and gain and transfer knowledge in a protected environment. It also incentivizes interactions and engagements, enabling users to earn GIL Tokens that they can spend on in-app goods and services, and allowing them to vote on the governance of the platform.

Parchment

Parchment is a widely adopted digital credential service, allowing learners, academic institutions, and employers to request, verify, and share credentials in simple and secure ways. The platform helps people, schools and universities exchange transcripts and other credentials globally.

3.4.3 Challenges to implementation

One obvious challenge for end users is that they require access to the internet, which is not available to all. A second major challenge is that blockchains are based on public-key cryptography. Users need public and private encryption keys to use the system. In current applications, these are often stored in a mobile phone. When the private key is lost, access to records is also lost. DLTs are often claimed to provide stable and portable records of educational history for migrants and in countries where war and social upheaval may destroy public records and institutional archives. Effective key management, however, is not necessarily easy in such contexts.

There are a number of additional technical and practical challenges to implementation. For instance, the process of verifying the blockchain information at multiple endpoints, simultaneously, requires huge amount of computing power, and electricity. This has a considerable impact in terms of energy generation and its related CO_2 emissions, becoming one of the key obstacles to the large-scale deployment of blockchain.

A number of technical standards and requirements for implementing interoperable DLT systems for credentialling and verifiable claims are currently under development. If blockchain solutions are to become widespread in education, global and national strategies will be needed to address standards and protocols to ensure large-scale uptake.

The ethical issues surrounding blockchains and digital ledgers require further research. There are those who suggest that, as yet, debates about blockchain are overly optimistic, and need to be framed in their broader sociological, political and ethical contexts. Blockchain secures the information that is added to the chain. However, it has no influence on the reliability or accuracy of the information that goes into the chain. In other words, if false, low-quality, or inaccurate information is added to the chain to represent 'true information', it will be harder to correct it or replace it with eventual revisions of that information. This is quite relevant in cases where there are disputes and revisions of documentation and registries such as land ownership that might be contested throughout the years.

Box 26 shows how blockchain is already supporting the use of badges for the recognition and verification of adult learners' competencies outside formal education.

Box 26. National Open Badge

The aim of this European Social Fund project, coordinated by the Oulu University of Applied Sciences, is to develop a nationwide open badge constellation, which enables the verification of adults' problem-solving skills in technology-rich environments by identifying and recognizing competences acquired outside the formal education system and in transition phases of the education structure. The open badges created by the project will be piloted within different target groups in TVET and adult education, including in preparatory training for TVET, integration training for migrants, adults' basic skills development, and upper-secondary TVET.

3.5 Cloud-to-edge developments

3.5.1 Overview of key elements

Another frontier development is the move from centralized cloud computing to localized edge computing, which opens a range of new learning and interaction possibilities. Whilst the cloud is the central hub for data processing and analysis, edge computing is where processing and analysis are enabled locally. As increasing decentralization of processing moves configurations from cloud to edge hubs, it enables organizations and local systems to gain control and affect processing closer to the point at which the data is produced and used. This requires smart devices and systems capable of processing and analysing data and sharing insights without the need for the data to be transported to a centralized server environment. Edge computing thus enables computational processes to occur at the point of interaction and allows analysis to take place on a local device in real time. This has many implications and possibilities for the future of education and hybrid learning models.

Table 12. Key features and benefits of cloud to edge

• Moves data processing and analysis from central clouds to localized hubs
• Enables greater local control and the ability to affect processing at the point at which data is produced and used
• Can potentially reduce cloud hosting and communication bandwidth costs
• Can improve data privacy and network efficiency, as well as reducing energy consumption, because it is a localized solution

3.5.2 Potential benefits for hybrid learning

As edge computing reduces the need for central processing, and as greater connectivity and bandwidth become available through developments such as 5G, it is possible to overcome key challenges to the effective integration of a range of interconnected and compatible developments, such as virtual and augmented reality, smart technologies and the internet of things (IoT). Edge hubs present a mechanism for delivering optimal digital experiences, using specially developed AI edge processors embedded in end-user devices or local servers, making it more feasible to develop rich, immersive and dynamic content that uses live data generated at learning environments. This could potentially foster a new culture and the use of context-sensitive digital pedagogies and customized applications suited to specific needs, a key requirement for more effective hybrid learning. However, more broadly, it offers possibilities for learners to be supported by AI that monitors, manages, facilitates and enhances learning, creating new configurations of teacher-student relationships, teaching organization and practice, and pedagogical approaches. This may challenge traditional notions of what learning entails and the spaces in which it occurs.

Table 13. Cloud-to-edge technologies: Benefits for (hybrid) learning

- Can enable the effective integration of interconnected and compatible developments, such as AI and AR, as well as interacting with live data being generated by the user
- Can support the development of richer and more immersive, interactive and dynamic learning experiences through individual devices
- Enables greater content customization and more contextualization of learning suited to specific needs
- May foster a new culture of context-sensitive pedagogies and customized applications

There are potentially longer-term benefits related to reduced cloud hosting and communication bandwidth costs. Localized solutions can also potentially reduce energy consumption and improve data privacy and network efficiency.

3.5.3 Challenges to implementation

There are numerous challenges associated with moving from cloud to edge. For example, it will require new distributed software architectures, and ways to distribute and orchestrate services. Traffic needs to be secured across local network nodes, and both the users and connected devices need to be identified using methods that do not rely on centralized nodes. There are obvious considerations of cost and return on investment, as well as deployment and integration, especially with regard to incorporation into rigid and structured education systems. As with any technological development, it has to be accompanied and underpinned by clear pedagogical strategies. Moreover, it will require coordinated global, national and local strategies for implementation, interconnected with other policies and strategies, to ensure equal benefits for all.

3.6 Frontier technologies' impact on hybrid learning: Scenarios

5G, AI, blockchain, and new cloud-to-edge architectures will elicit a range of scenarios related to their future use. Across foresight work in the field of education, scenarios range from those that situate frontier technologies as a solution to existing challenges; to those that envisage systemic restructure; through to those that question the very nature, relevance and purpose of education.

Below, we present three brief, general scenarios related to each of the four frontier technologies and their impact on the future of hybrid learning. These are presented as neither predictions, nor a wish list, but merely as a means to support dialogue, debate and reflection.

The ideas compiled in these three scenarios benefited from a foresight exercise and the OECD (2020) publication "Back to the Future of Education: Four OECD Scenarios for Schooling", produced as part of the work on Trends Shaping Education, under the leadership of Tracey Burns, Senior Analyst in the OECD's Centre for Educational Research and Innovation, and member of the Broadband Commission Working Group on Digital Learning.

Hybrid Scenario 1: Systems Extended
The impact of frontier technologies
The existing system adapts to new developments and opportunities to create enhanced and enriched learning experiences, tailored to need. Comprehensive connectivity and greater bandwidth facilitate access to learning through multiple sites and any compatible device via a growing array of platforms and repositories, meaning those students who cannot attend an institution have access to quality learning content. However, the quality of this varies across the system. It has developed in a piecemeal manner, and access is largely shaped by institutions and individual providers. Feedback and assessment processes have become quicker and more tailored to individual learners, and are enhanced considerably by the incorporation of intelligent and automated assessment systems and tools, generating automatic questions, tasks, summative grading, and content suggestions aligned to learning plans. Effective incorporation of machine intelligence and transfers between networks and systems has enabled institutions to develop more targeted learning strategies, and has also greatly improved systems management, performance monitoring and reporting. Educators have access to a vast array of content and OER, which they are able to collect, collate, curate and customize to learners' needs, as well incorporating additional learning and performance analytics tools, including plagiarism detection. A suite of tools and applications have been incorporated to make learning content not only more engaging but more accessible. Educators have access to a greater number and breadth of resources that are accessibly designed, as well as materials that can be adapted for specific needs. Diagnostic tools for learning difficulties are also embedded into learning analytics. Lower latency and more effective communication and collaboration tools mean that learning across and between different groups is now common but is used largely as a mechanism to enhance existing approaches and schemes of work. Similarly, there have been great advances in learning in, and from, different environments but for most compulsory settings this is limited by curricula, existing cultures and practices, assessment and examination requirements, and systemic management and performance measures.

Developments in AI, coupled with more connectivity, bandwidth and edge processing, have substantially increased the use of more interactive and immersive digital content. Teaching practice has evolved and digital technologies are seamlessly used in day-to-day teaching and learning. However, the purpose of their incorporation and underlying predominant practices and pedagogies remain largely unchanged.

Blockchain has begun to support micro-learning and micro-credentials, and to assure qualification authenticity for both students and new employees, reducing the need for third-party authenticity checks. However, system-wide use of micro-accreditation has not yet been fully integrated, and remains peripheral and additional to formal end-point qualifications. It has yet to be incorporated as a means of providing consistent quality amongst digital resource providers.

Why we learn:

The purpose, structures and processes of education remain largely unchanged. The parameters of what is learnt in formal settings are structured and driven by existing curricula, assessment, examination, and performance measurement mechanisms. This mediates possibilities relating to what, when, how, and with whom we learn. However, technological and pedagogical developments increase the customization of learning and support the emergence of new digital teaching and learning approaches, as well as new models of hybrid education.

How we learn:

The degree of additional learning opportunities, experiences and content afforded by new digital technologies begins to challenge existing notions of educator-learner-institution relationships and the ways in which education is structured and organized.

Who we learn with and from:

New communication and collaboration tools facilitate more diverse learner configurations and collaborations; however, existing systemic and institutional requirements mediate the extent to which fuller possibilities are explored. AI developments facilitate greater machine and human-machine interactions and feedback, and educators incorporate this into plans for learner progression and development, creating more customized learning.

What we learn:

What we learn is still largely constrained by set requirements. However, a growing number of knowledge sources and providers enable specialization based on individual and contextual needs.

Where we learn:

This remains largely unchanged but technological developments result in significant advances in learning 'in-situ', remotely, and through online environments. These begin to challenge existing notions surrounding institutional attendance. Access to quality digital experiences is a crucial part of provision for those who cannot attend institutions, as well as a resource for extending learning opportunities beyond the classroom.

When we learn:

When we learn remains largely based around existing systemic requirements to attend an institution at set times at most levels, despite the increasing prevalence of access to digital resources from any location. The predominant model looks increasingly outdated as different sectors and providers develop flexible and effective digital hybrid models that challenge predominant notions of where and what a learning space is.

Hybrid Scenario 2: Systems Restructured
The impact of frontier technologies
There has been a significant move away from traditional configurations of education around highly structured and rigid system and institutional requirements and associated performance and qualifications systems and measures. New configurations have utilized digital developments to harness a wider global infrastructure of hybrid learning possibilities, and institutions are increasingly being repurposed and restructured as learning hubs. However, developments are uneven and both new and old models co-exist. Greater bandwidth, comprehensive connectivity and increased stability facilitate access to a growing array of platforms, repositories and content for all, from any location. This also caters for large numbers of users being online at the same time, engaging with a richer and more diverse set of interactive and immersive content types. This has enabled institutions to reconfigure where and when learning takes place, and repurpose the organization and function of schools, colleges, universities and other educational spaces. With far less compulsion to attend an institution, this has in turn facilitated considerable and more diverse in-situ, geo-located and on-the-job learning possibilities that can readily be linked and connected to learning hubs, repositories and storage systems. Developments in AI, AR and VR, and associated connectivity, bandwidth and local edge processing, enable engagement and interaction with more dynamic and immersive content. Local data processing, facilitated by shifts from cloud to edge computing, enables significant content customization and the employment of context-appropriate resources and pedagogies. Such approaches are becoming increasingly commonplace in all learning stages and sectors. Learning across institutions and trusted communities globally is a core part of provision, shifting the emphasis away from learning in defined groups or institutions. Enhanced collaboration and communication tools enable greater specialization through new learning networks, moving beyond knowledge acquisition toward information exchange, collaborative knowledge construction, and the development of new learning artefacts. Shifts toward more learner-centric and co-constructed approaches are no longer between a single learner and teacher but between numerous individuals, groups, and networks, mediated by AI. New pedagogical practices are emerging, with facilitation and mentoring roles complementing more traditional teaching practice. Automated and intelligent assessment and teaching tools support and guide learners, enabling greater personalization and diversification. The introduction of synthetic and intelligent 'teachers' is also being explored to examine how educators' abilities and knowledge might best be refocused in hybrid environments. To more effectively respond to greater diversification, the system is shifting away from rigid means of learning and accreditation and toward micro-learning and micro-credentials, using trusted networks that incorporate blockchain accreditation, verification and associated incentives. Big data and data transfers also underpin these changes, enabling information on learner progress, needs and attainment to be exchanged across locations, networks and platforms, ensuring continuity of customization of provision. Accessibility is a central aspect of all digital content and infrastructure developments. Inclusive, accessible and equitable design is a key feature of the regulation of content providers and whether or not they can participate in trust networks.
Why we learn: Education shifts in response to wider societal evolution and the need to support knowledge and skills development in a rapidly changing world. There is a shift from systems based on fixed and imposed content, curricula and syllabuses, to one that is learner-centric, co-constructed and negotiated. More emphasis is placed on interacting with new digital information and building new knowledge, artefacts and relationships. Learning is reconfigured to be driven more by the learners' interests, needs and kinds of support they require in order to learn effectively. Greater emphasis is placed on skills and competency development over the life course, in response to changing circumstances and contexts.

How we learn: Increasingly, how we learn becomes flexible, with new configurations being made possible through technological developments and a wider drive to make learning more personalized. As a result, learning becomes a more co-constructed and learner-directed endeavour, resulting in educators being increasingly recast as mentors and facilitators.
Who we learn with and from: Traditional structures, processes and performance mechanisms are overhauled to facilitate decentralized relationships and practices, and provide diverse learning pathways and routes through a network of interconnected institutions, communities and content providers, further augmented through machine intelligence.
What we learn: Learning is reconfigured to be driven by students' interests and needs, as well as the wider resources they require to learn effectively.
Where we learn: Whilst there are still general systemic requirements, increasingly the location in which learning takes place becomes a blurred and negotiated decision and it occurs in hybrid environments across the whole learning ecosystem.
When we learn: New technological developments have supported moves toward flexible arrangements to suit learners, and the times, spaces and places for learning are no longer fixed or defining characteristics of education systems.

Hybrid Scenario 3: Systems Reinvented
The impact of frontier technologies
Greater bandwidth and stable connectivity offer access to rich learning through multiple sites and platforms. Moreover, it provides the basis for action and problem-based learning 'in-situ'. It also provides seamless access via automated log-ins from any location and the ability to download rich data and receive instant feedback from human mentors or through intelligent systems. Local processing and data analysis mean that rich data sets can be incorporated into learning episodes to provide the basis for real-time, contextualized and geo-located learning. Live data can be fed back into systems from the location in which it is collected and generated, which is particularly valuable for action- and problem-based learning. Developments in AI enable simulations, visualizations, modelling, forecasting and diagnostics in 'field' settings and also homes and institutions. Exploratory and immersive environments that respond to learner input provide tangible explorations of real-world problems simulating the results of inputs from learners, scaffolded by AI assistance and guidance. Micro-learning and associated micro-credentials have become the dominant mode for accreditation, ensuring that both prior experience and new skills and competencies are captured and accredited at the 'point of learning' to provide individual and system-wide motivations for engaging with learning for change. Enhanced communication tools enable learners to take part in action-based learning through both trusted local community nodes and networks, and trusted and verified partners in the global alliance for change, facilitated by blockchain developments. Trusted networks also provide the basis for the accreditation and validation of content providers. Big data and data transfer mean that learning in all settings is personalized, captured and visible across learning sites.

The change in emphasis necessitates new approaches and pedagogies that are learner-centred and co-constructed through learner-partner relationships and facilitated through mentor-facilitator hubs. Professional development models move increasingly toward micro-accreditation through communities of practice, with near-field communication technologies being used to capture progress in action through self, peer, community, or other external validation.
Why we learn: Why we learn is radically repurposed in response to external challenges, which repositions education as a fundamental lever for change. Climate change results in an epoch-defining shift and education is reconceived as a global, collective endeavour. Learning and teaching are informed by humanist principles and critical pedagogies, orientated toward self-actualization, engagement in problem-solving, tangible and meaningful knowledge creation, and action-based learning.
How we learn: There is emphasis on the collaborative acquisition, creation and implementation of knowledge, and a significant concentration on real-world, problem-focused and action-based learning through trusted learning communities and alliances.
Who we learn with and from: Learning becomes a co-constructed process based on opportunities to learn between multiple networks and partners in communities of trust, driven by both individual and global interests and needs.
What we learn: What we learn is based on individual and environmental needs. Learning builds on interest, existing competencies and prior experience. Traditional distinctions between formal and informal learning become increasingly blurred.
Where we learn: There is a particular shift in emphasis toward learning in borderless online communities, as well as problem- and action-based learning in the field. Formal institutions increasingly act as hubs to support learning in wider communities of practice and action, and learning becomes more likely to take place at the point of need, wherever that may be.
When we learn: New technological developments have supported moves toward flexible arrangements over when we learn, whether this is synchronous, asynchronous, offline or online. Increasingly, when we learn becomes negotiated.

Hybrid learning and environmental sustainability

Climate change results in an epoch-defining shift and education is reconceived as a global, collective endeavour. New inter- and intra-national learning collaborations are established. This shifts the purpose of learning from a more rigid and prescribed model to one that is not only emergent, but is clearly linked to wider values associated with reducing global and local inequality, ensuring democratic participation and access, and addressing the climate crisis.

The production, manufacturing and consumption of digital devices and technologies currently contribute to global emissions, and have been identified, in some cases, to be linked to highly unethical and unsustainable practices. From this perspective, environmental sustainability and the further expansion of digital technologies seem mutually exclusive. Yet, examples elsewhere demonstrate that the design and application of digital technologies can be used ethically to reverse or reduce environmental degradation. The belief in their ability to reverse or halt climate change, however, is highly debatable and possibly even a distraction from the need for radical cultural, social, economic and political transformations that enable us to change our consumption behaviours and production practices.

The IPCC's Sixth Assessment Report (2021) clearly identifies the gravity of our current situation. Combining digital developments with more sustainable practices must be at the forefront of responsible strategic business and political planning, not least to address longer-term viability as customers, regulators and government perspectives change in response to the climate crisis. If the purpose of a frontier technology is to apply new developments to address wider social challenges, then extending existing unsustainable practices and approaches not only defeats the object but adds to those very challenges.

3.7 Conclusion

Frontier technologies provide a basis to reconsider how future economies, societies and education systems might be shaped, developed and organized. This chapter considered current key frontier developments including AI, machine learning, big data and data analytics, 5G, blockchain and distributed ledgers, and cloud-to-edge technologies. Three general scenarios related to the future of hybrid learning facilitated by these technologies were considered: 'systems extended' (the existing system adapts to new developments and opportunities to create enhanced and enriched learning experiences, tailored to need); 'systems restructured' (a significant move away from traditional configurations of education around rigid system and institutional requirements and associated performance and qualifications systems and measures); and 'systems reinvented' (climate change results in an epoch-defining shift and education is reconceived as a global, collective endeavour and new inter- and intra-national learning collaborations are established).

Recommendations

In the light of their findings, the members of the Broadband Commission Working Group on Digital Learning recommend that governments and other stakeholders take the following five actions:

1. Promote hybrid learning to recover from the pandemic, reimagine education, and narrow the digital divide

Governments and national stakeholders should decide which models of hybrid learning are the most appropriate and identify the contexts and situations where they may work best. The pedagogical focus should be on student-centred, active and collaborative learning. However, further research is needed to identify how hybrid learning can best integrate these pedagogical approaches.

Moreover, stakeholders should recognize the central role played by teachers and support staff as agents of change, and deliver adequate training and in-service professional development, together with initiatives to nurture their well-being, mental health, communities of practice, and peer learning activities.

Open educational resources (OERs) and other free-of-charge and quality-assured digital content should be promoted and aligned to national curricula, cultures, languages and identities. Ultimately, hybrid learning models, like their traditional counterparts, must be designed with a focus on inclusion and equity, prioritizing those who are most at risk of being left behind, including low-income students, women and girls, persons with disabilities, people on the move, migrants, refugees, and other marginalized groups.

2. Adopt a national strategy for digital skills development for life, work and lifelong learning

The Working Group members recognize that capacity gaps remain a persistent barrier to narrowing the digital divide. Governments must increase their efforts toward skilling, reskilling, upskilling and capacity building to leverage digital technology for life, work and lifelong learning and other socially beneficial purposes. This is especially urgent for disadvantaged groups including girls and women, and young people who are not in education, employment or training (often known as NEETs).

In order to foster a digitally ready society, national stakeholders should define system-wide strategies for skills development designed to address specific social and economic needs in today's society. These strategies should be based on robust national digital skills assessments and align with hybrid learning requirements and the government's goals and plans to embrace digital transformation. They should also refer to available international digital skills frameworks and taxonomies and adapt them to the country's needs. This will provide a reference structure and tools for assessment, certification, monitoring and evaluation, and allow for comparative analyses across regions. Furthermore, a government should engage all relevant stakeholders when designing and implementing its digital skills strategy, and strive to leverage existing private and public initiatives, competences and investments.

3. Promote whole-of-government and public-private partnership approaches for connectivity and infrastructure

Government and state actors play a leading role in setting the conditions for sustainable and equitable provision of education and training. They should continuously promote cross-ministry coordination, joint initiatives and policy alignment for connectivity and infrastructure in relation to hybrid and remote learning. This can be accomplished by developing appropriate governance and regulatory frameworks; planning and coordinating national policies and implementation strategies; creating and managing public-private partnerships; and mobilizing and efficiently exploiting resources.

Success hinges on public and private entities sharing a common vision and understanding each other's contribution. This should be demonstrated both in official documentation and in practice on the ground. To measure progress in terms of access and outcomes, national stakeholders should collect and disseminate data and information regarding the digital divide, hybrid learning, access to connectivity and infrastructure, and the digital transformation of education and training systems.

Private-sector organizations operating in the hybrid learning ecosystem need to be regulated, especially regarding the use of proprietary tools and services in education. Stakeholders should also encourage the educational technology industry to act as an essential partner in building thriving local ecosystems and promoting the local development of frontier technologies for education. For this purpose, instead of public education and training bodies viewing this industry just as a provider of goods and services, they could consider other types of relationships with them, including partnerships for funding, research, internships, apprenticeships, and collaboration to develop standards.

4. Establish stable and sustained financing of connectivity for hybrid learning

Financing quality education, including digital transformation, remains a major challenge, particularly in low- and middle-income countries. During the past decade, government spending on education increased steadily; however, the pandemic constrained public finances and hindered prospects for sustaining these positive increases. As a result of the public health crisis, most governments in low- and middle-income countries were only able to invest in education with the support of the international community and private industry.

Reliance on ad-hoc initiatives and donor funding does not represent a long-term, stable financing solution (which is necessary for achieving the SDGs). Given that connectivity and hybrid learning are not 'one-time' expenditures, they should be featured in institutions' budgets (as a recurring cost) and, ideally, part of the government's broader educational policies and sector plans. More robust, predictable, and sustained investments are necessary.

A hybrid-learning policy and costing approach requires all significant elements, enablers and building blocks of the hybrid learning ecosystem to be considered. It requires coherent, systemic and ongoing efforts by the public sector, even if it relies on commercial or community models, to provide financial and/or regulatory incentives for telecommunications infrastructure. Countries with a demonstrated ability to execute such investment coherence are more likely to reap the benefits of hybrid learning.

To enhance the efficacy of hybrid learning, governments can consider as a guideline this report's suggested model for integrating digital transformation into education policies and sector plans. Additionally, they may adopt the report's proposal for a roadmap for rolling out connectivity in their schools through an iterative five-step process from framing the initiative to selecting technological provision and funding methods and finally determining which operating model to implement. Stakeholders should engage in a policy and social dialogue on the cost-effectiveness of different implementation models.

Because a self-sustaining and comprehensive hybrid learning investment framework concerns the whole of government and many sectors and types of partners, it requires a cross-sector policy framework, participatory planning, and social dialogue.[27] Future investment decisions should be addressed in policy dialogue; however, financing the hybrid learning transition and transformation may also build on existing levels of cooperation among various stakeholders. Each country has its own history of trust and collaboration between government and private sector financing, such as delivery schemes, resource allocation models (supply- or demand-oriented), and even the administrative structures and processes for digitally oriented educational reforms. Financial resources and competing needs will influence the decision-making from country to country, as will the structural features of education, ICT and telecommunications governance and existing financing frameworks. In summary, no single approach is appropriate for all societies and educational systems.

5. Proactively anticipate the impact of emerging technologies

Hybrid learning together with the requirements related to digital skills and competencies constitute an area of education that is changing continually in tandem with the development of new technologies. The Working Group discussed the rapid growth of 5G mobile internet access, Wi-Fi 6 wireless access, cloud-based computing, AI and blockchain.

National stakeholders should anticipate the impact of frontier technologies on education through foresight exercises, scenario building, data monitoring, and qualitative as well as quantitative research. The resulting information will help guide the development of hybrid learning systems and resources. This in turn will contribute toward empowering teachers, enhancing lifelong learning, improving methods of assessment and certification, and putting innovation to work to solve educational problems and inform investment decisions.

Governments should mobilize interdisciplinary and multi-stakeholder expertise to inform and build the capacities of policy-makers. In doing so, they can more easily develop and implement appropriate policies and regulatory frameworks for the ethical and human-rights-based use of frontier technologies, regarding learners' data protection and security.

Finally, combining digital developments with more sustainable practices must be at the forefront of responsible strategic business and political planning.

27 The government will have to continue to be responsible for educational improvement and expansion, and education will likely continue to be financed publicly. The public sector will need to continue setting hybrid learning standards and decide how to allocate resources.

Acronyms

3G	Third generation of wireless mobile telecommunications technology
4G	Fourth generation of wireless mobile telecommunications technology
5G	Fifth generation of wireless mobile telecommunications technology
AI	Artificial intelligence
ANATEL	Brazilian National Telecommunications Agency
AR	Augmented reality
BBC	Broadband Commission for Sustainable Development
Capex	Capital expenditure
Cetib.br	Regional Centre for Studies on the Development of the Information Society
CGI.br	Brazilian Internet Steering Committee
CIEB	Centre of Innovation for Brazilian Education
DFI	Development finance institution
DNS	Domain name system
DLT	Digital ledger technologies
ERPG	Federal Government's Economic Recovery and Growth Plan
FMoCD	Federal Ministry of Communications and Digital Economy
FNO	Fibre network operators
GB	Gigabyte
Gbps	Gigabyte per second
GDP	Gross Domestic Product
GEC	Global Education Coalition
GEF	Global Education Forum
GER	Gross enrolment ratio
GICE	Inter-institutional Group on Connectivity for Education
GNI	Gross national income
GSMA	Global System for Mobile Communications Association
HL	Hybrid learning
IADB	Inter American Development Bank
ICTs	Information and communication technologies
IMF	International Monetary Fund
INEP	Instituto Nacional de Estudos e Pesquisas Educacionais
IoT	Internet of things
ISCED	International Standard Classification of Education
ISP	Internet service provider

IT	Information technology
ITS	Intelligent tutoring systems
ITU	International Telecommunication Union
JV	Joint venture
LAC	Latin America and the Caribbean
LTE	Long-term evolution
MB	Megabyte
Mbps	Megabyte per second
MDB	Multilateral development banks
MOOC	Massive open online courses
NERDC	National Education Research and Development Council
NGOs	Non-governmental organizations
NIC.br	Brazilian Network Information Centre
NREN	National Research and Educational Network
OECD	Organization for Economic Cooperation and Development
OERs	Open educational resources
Opex	Operational expenditure
PPP	Public-private partnership
RFPs	Request for proposals
SDGs	Sustainable Development Goals
STEM	Science, technology, engineering and mathematics
UIS	UNESCO Institute for Statistics
UN	United Nations
UNCRC	United Nations Convention on the Rights of the Child
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Emergency Fund
USAF	Universal service and access funds
USF	Universal service funds
USAID	United States Agency for International Development
VR	Virtual reality
WISP	Wireless internet service providers
Wi-Fi 6	IEEE 802.11ax standard for next generation high-speed wireless local-area network

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Working Group Report on Digital Learning

Connecting Learning Spaces:

Possibilities for Hybrid Learning

September 2021

Compendium

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I. Country examples

I.1 Delivering hybrid learning

I.1.1 Uni and multi-modal formats

Country: **Colombia**
Title: [Aprender digital [Digital Learning]]
Implementer: **Ministry of Education in collaboration with the Ministry of Information and Communications Technology**
Short description: In order to support the continuity of learning during the COVID-19 pandemic, the Colombian Government adopted a free access and multi-channel approach. The Ministry of National Education (MinEducación) worked closely with the Ministry of Information and Communications Technology to deliver more than 80,000 computers with preloaded educational content (that work with or without connectivity) to teachers and students from rural areas. Educational resources were also provided, for free, to the educational community through *Aprender Digital* platform. These are available in diverse formats, including web articles and newspapers, 3D interactive games, eBooks, digital libraries, video lessons, audiobooks, videos and virtual learning objects, offering different options for learners to continue with remote study. The Ministry of Education also created a teacher platform known as "*Contacto Maestro*" ["Master Contact"], which would be focused on supporting teachers and school leaders through the facilitation of webinars and asynchronous training.

Online, digital and interactive learning strategies have been combined with the broadcasting of educational content both on radio and on television. With the support of Radio Television Nacional de Colombia (RTVC) - [The National Radio Television of Colombia] and other regional public channels, educational and pedagogical content is broadcasted in progams like: "*Profe en Tu Casa*" ["Teacher at Home"], which aims at strengthening academic knowledge and skills: "*3,2,1, Edu Acción*" ["3,2,1, Edu Action"] for learners of all ages with the aim of reinforcing educational skills in different subjects; and "*Mi señal*" ["My Signal"], produced by an alliance of local channels and community radio stations, supporting the work from home of students and teachers, whose target is the rural audience. Additionally, through the main national media station the government has included pedagogical guides that seek to strengthen transversal skills.

Country: **Federal Republic of Mexico**
Title: [Aprende en Casa (Learning at Home)]
Implementer: **Ministry of Education**
Short description: Mexico's *Aprende en Casa* (Learning at Home) was created by the Secretary of Public Education to provide pedagogical and country-wide continuity to 25 million students of all educational levels following the closure of schools due to the COVID-19 pandemic. The backbone of the initiative is educational television; a field in which Mexico has long-standing experience gained since the creation, in 1968, of *Telesecundaria*. This is a national literacy-based initiative involving the production of

television programmes to aid learning for secondary schools in rural and isolated areas. It is implemented by the General Directorate of Educational Television). *Aprende en Casa* has specific slots for each educational level which are broadcast through television and Internet platforms offering complementary resources. It includes a special radio strategy that reaches students from local communities by airing programmes in 15 different languages through a network of community and indigenous radio stations and the National Institute of Indigenous People.[1]

Country: **Federal Republic of Nigeria**
Title: **Edo-BEST@Home**
Implementer: **Edo State Ministry of Education**
Short description: When Nigeria's Federal Ministry of Education (MoE) closed all schools in mid-March 2020, the State of Edo launched Edo-BEST@Home. This is a mobile-phone based remote learning programme that extends the pre-existing Edo Basic Education Sector Transformation (Edo-BEST) programme, a Public-Private Partnership (PPP) between the Edo State Basic Education Board, the World Bank, and Bridge International Academies. The programme focused on a unimodal solution to provide remote education to all students across the state, from pre-primary to junior secondary (middle school), with four key aspects: (i) providing engaging programming focused on content aligned to the curriculum; (ii) constant support from teachers and parents to students; (iii) formative assessment in the form of interactive quizzes; (iv) on-going support to teachers through virtual coaching. The single-mode programme includes interactive audio lessons, digital self-study activity packets, digital storybooks, mobile interactive quizzes, learning guides for parents, and virtual classrooms that enable interaction between teachers and students. Students now have access to four hours of interactive audio lessons that are aligned to Edo's curriculum, digital self-study activity packets that are distributed through WhatsApp and online, and mobile interactive quizzes for students to use at home every day.

I.1.2 Focus on equity and inclusion

Country: **Republic of Korea**
Title: **Overcoming the digital divide**
Implementer: **Ministry of Education**
Short description: The Korean Ministry of Education has provided tailored educational support for students from low-income families without digital devices (e.g. educational grant recipients), as well as those from families with multiple children, single-parent families, families in which primary caregivers are grandparents. In the first semester of 2020, 283,000 digital devices were provided, followed by 263,000 digital devices in the second semester to students in need. In addition, from April to December 2020, Korea adopted the zero-rating policy to make mobile data free of charge for educational websites.

Through the Priority Project for Education Welfare, tailored support for vulnerable students was provided. As a result, emergency supplies and learning packages were offered and online learning was supported through the provision of digital devices and guidance on how to use them. As of 2020, 330,000 students from all 17 metropolitan and provincial offices of education benefited from this service. Multicultural students were guided in the use of various online materials, including video content for Korean language classes (222 classes in 2020; 96 classes in 2021). In addition

1 Ripani and Zucchetti, 2020

to this, the Central Multicultural Education Centre and the regional multicultural education support centres worked together to develop multi-lingual guidance for parents in multicultural households.

To provide tailored educational support to students with disabilities, an "online learning site for students living with disabilities" was established. A total of 4,247 teaching and learning materials were produced for different types of disability needs, and the government covered the cost of data incurred by using the site. In particular, for students living with disabilities who have difficulty participating in online classes, learning packages were offered by considering the type and degree of their needs. Also, 1:1 or 1:2 in-person education (at school or home) was also offered.

Country: **Saudi Arabia**
Title: The Madrasati Platform
Implementer: **Ministry of Education**
Short description: The Madrasati Platform (Closing the digital divide) is the national Learning Management System of the Ministry of Education (Madrasati Platform). One of the principle aims of Madrasati [My School] is to ensure that students, teachers, education staff and parents have equitable access to distance education and training regardless of their geographical location, income or physical abilities, thus enhancing equalities among them and preventing early school dropout due to poverty. Launched in August 2020, the platform targets more than 6 million users (98% of students) in all governorates and provinces of the kingdom. Students' lack of computers was resolved through low-tech options for education (i.e. radio and television programmes) that do not require computers. Internet services were facilitated to overcome technical hitches and obstacles that may hinder students learning. Readiness to adopt distance learning was achieved by providing training sessions and materials, usage guides, educational messages, and videos to help educate and prepare all stakeholders to accept and use distance education platforms and other available options positively. The infrastructure capacity was enhanced by utilizing Cloud services to host the unified education system to ensure quality performance and serve a significant number of users.

Country: **Kenya**
Title: JWL HeLP **(Humanitarian e-Learning Platform)**
Implementer: **Ministry of Education**
Short description: Refugees and the forcibly displaced populations have numerous challenges in accessing quality education, including hybrid learning. These include: access to connectivity and devices, lack of identity documentation, limited recognition of prior learning, the inability to enrol in national schools, language and cultural barriers, and prolonged interruptions in their learning. In 2018, and in collaboration with Seitwerk GmbH, Jesuit World Learning (JWL) developed its own Learning Management System (SIS/LMS), now known as JWL HeLP (Humanitarian e-Learning Platform) – to mitigate some of the challenges faced by refugee learners. This online/offline solution was developed over a period of 12 months and includes an application which works on multiple Android and Windows devices. It was first piloted in autumn 2018, for the Youth Sports Facilitator (YSF) professional certificate course (in Kakuma Refugee Camp and Dzaleka Refugee Camp). Students enjoy access to a range of learning materials and assignments that can be completed and submitted without having to travel to the learning centres. Content can be downloaded or uploaded via computer. Students are provided with tablets or other mobile devices allowing them to study anytime, anywhere, with a range of resources at their fingertips. When online, they are able to interact with

peers both locally and from around the world, leading to further understanding and open-mindedness about different cultures and traditions, enriching their discussions, and overcoming borders.

I.1.3 Focus on pedagogies

Country: **Vietnam**
Title: High Touch High Tech approach
Implementer: **Ministry of Education and Training (MOET) in partnership with the Education Commission and Arizona State University (ASU)**
Short description: This is an adaptive learning prototype programme called 'the High Touch High Tech for All approach'. High Touch High Tech for All aims to deliver personalized learning for all students by combining the unique strengths of the teacher (High Touch) and the power of technology (High Tech). The technology provides adaptive content and assessment to develop students' foundational skills while the teacher cultivates students' higher- order skills such as critical thinking, collaboration, and socio-emotional growth. Vietnam's Ministry of Education and Training, the Education Commission, and Arizona State University worked together to develop an adaptive and active learning prototype program for 7th grade math. The focus on math aimed to help students who struggle and subsequently lose interest in STEM. The prototype, which utilized the High Touch High Tech approach, harnessed an adaptive instructional system to help students develop math skills mastery and prepare them for solving higher order problems with the guidance of their teacher through active learning.

The objective of the prototype was to re-think the roles of the education workforce, including the use of digital technology and adaptive learning, for both teachers and students to achieve subject mastery. For students, it offered an opportunity to learn and master subjects through more personalized learning approaches, with teachers engaged in more directed and active teaching to help students become master learners of subjects. Because the content is tailored to the needs of the students, they and their teachers can address troubling areas long before the students have to demonstrate their knowledge in an exam. Thus, they become master learners of subjects rather than "master exam takers."

Teachers were trained on how to use the adaptive system (McGraw Hill's ALEKS software) using an experiential approach where teachers completed the adaptive math course themselves. This provided both an orientation to the platform and an 'initial knowledge check' of teacher subject knowledge to identify where they might need additional support. Teachers also created additional course content, producing videos of digital instruction in Vietnamese and a library of active learning math exercises. In trialing the prototype, support mechanisms included regular "temperature check" surveys for teachers to monitor their levels of understanding and comfort, school visits to review implementation progress, a professional development workshop with key stakeholders, and remote support.

A team of researchers from the Korea Advanced Institute of Science and Technology, Yonsei University, the University of Illinois, and Seoul National University conducted an external evaluation to examine the effectiveness of the HTHT approach. The prototype was tested in four junior high schools – two in Hanoi and two in Ho Chi Minh City (8 teachers and 531 students) and compared with three control schools (14 teachers and 832 students). There was a statistically significant impact on student learning: the adaptive and active learning prototype increased treated students' math test scores by 0.436 standard deviation- an equivalent of two years' worth of learning in just one semester. Furthermore, there appears to be greater benefit for lower performing students. Results from teacher surveys showed significant gains in teacher perceptions on the utility of adaptive tools to facilitate student learning (gains of 0.83 standard deviation) and improvement in their personalized teaching practices to drive curriculum (gains from 0.78 to 1.80 standard deviations).

The Education Commission is now expanding the High Touch High Tech approach in other countries including an ongoing 97-school pilot in Uruguay, a potential feasibility assessment in Vietnam, and potential pilots in Southeast Asia. It is also establishing the High Touch High Tech for All Global Consortium.

Country: **United States: United States of America**
Title: **Intentionality strategies for learners with special education needs**
Implementer: **Hunterdon Central Regional High School in New Jersey**
Short description: This hybrid model may call for changes in classroom norms. Students with learning disabilities tend to display struggles with embracing change and adjusting to new technologies and structures while maintaining their productivity. Many students show signs of frustration, lack of focus, a decrease in motivation, and negative attitudes. One special education teacher at Hunterdon Central Regional High School in New Jersey decided to promote the idea of 'intentionality' within a hybrid learning environment, a metacognitive strategy that can help students with learning difficulties or disabilities focus on those things they can control and monitor their actions and behaviours. Intentionality was focused around specific strategies for all learners. These include:

1. Bolstering positive behaviours: conduct a climate observation within the classroom. What behaviours are lacking among students?

2. Create expectations together as a class: students with learning disabilities value rules that other students might not recognize. For example, the idea of "wait time"—not many students value this because they've never heard of it. When teachers ask a question and then wait before calling on anyone, it can make a significant difference in everyone's learning. Teachers can set up opportunities for creating rules and expectations unique to each classroom. These rules aren't set in stone—teachers and students can revisit and improve them. For students with learning disabilities, their voice is particularly important within this creation of classroom norms. 3. Set the stage: All learners should be able to access a daily agenda ahead of time in order to mentally prepare. Students with learning disabilities in particular can benefit in many ways from the predictability of this strategy in that it can help to decrease anxiety about unknowns in the day ahead.

4. Take advantage of nonverbal communication: Sometimes communication is tough in an online classroom—voices can be muffled, and people may speak over one another without knowing it. There are times when just interrogating individual understanding can take a long time. Both remote and in-class learners can benefit from systematic use of gestures that convey understanding and decrease the chance that learners will lose focus, flow, and motivation.

5. Set up revolving leadership roles: Select leaders for each hybrid class, a leader from the remote group and one from the in-class environment. These two learning leaders can offer support by taking notes, directing

participation, and boosting motivation by offering positive praise, sending thumbs-up and/or hand-clapping *emojis* on Zoom, playing motivating music before class, and/or taking suggestions for fun break time activities. Before each class, prepare the leaders with an outline or plan for the upcoming class. This can increase the self-confidence of students with learning disabilities and provide them with an opportunity for voice and decision making.

6. Make time for personal connections: Give students three minutes at the beginning and end of every class to reflect, share plans for the weekend, ask questions, organize themselves, or simply just catch up with one another. This is a simple strategy that really pays off. When students with learning disabilities are provided time to transition into the start of class, they display more focus and engagement.

Country: **United States: United States of America**
Title: XQ schools
Implementer: **State Departments of Education and school networks**
Short description: XQ schools are a network of public high schools across the USA oriented toward the future of education. The XQ Institute partners with students, teachers, and communities to re-design secondary education and transform the learning experience around the Enriched Virtual model. Participating schools include:

- Latitude High in Oakland, California was designed around students' desire for real-world, hands-on learning. Students spend most of their time in the community, interacting with experts and companies to develop a career orientation and undertaking project-based learning where they live. Teachers co-create education plans for each student, and mentor them throughout their plan. Classes are multi-disciplinary workshops that take place around the city and allow students to carry out work typical of journalists, engineers, designers, etc.

- Brooklyn Laboratory High School in New York serves a diverse student body that is largely low-income with a substantial number of special needs learners. They use a digital platform that provides teachers and students with a data dashboard that is updated daily. Students are required to show mastery of content before progressing, and the use of updated, personalized data helps teachers support this goal and assists students to better understand their own learning needs. Teachers are recruited locally to ensure a level of diversity that mirrors the student body. A strong professional development "residency" programme requires new teachers to enrol in graduate courses to obtain certification, and to co-teach with experienced teachers.

XQ has partnered with the State of Rhode Island and its Department of Education on a design competition including all 64 public high schools. The competition was conceived in response to emergent needs that surfaced from the COVID-19 pandemic and a long-standing desire to "educate original thinkers". The top schools from this design phase were selected to receive grants to develop schools around "meaningful, engaged remote learning". They learned the importance of building relationships with students from the start, and equipping parents with curricular knowledge as well as the digital skills to navigate the online learning tools.

I.1.4 Focus on education content and open education resources

Country: Republic of India
Title: DIKSHA (Digital infrastructure for school education)
Implementer: Ministry of Education
Short description: DIKSHA is India's digital infrastructure providing quality e-content for school education in states/UTs as well as QR-coded energized textbooks for all grades (one nation, one digital platform). DIKSHA is premised on the core principles of open architecture, open access, open licensing, and diversity in choice and autonomy. The platform is built on open-source technology which incorporates internet scale technologies and enables several solutions for teaching and learning. Key components within DIKSHA are as follows: contextualised digital courses for supporting teachers in their professional development; games and exercises to test and increase cognition; assessments to gauge the understanding of a topic/chapter/unit and help for teachers to improve the overall learning experience; video and audio clips to explain concepts creatively; interactive games or exercises to stimulate cognition; worksheets to assess understanding of particular topics/units/chapters; images (pictures, drawings or photographs) to explain concepts and different contexts; quizzes with interactive tests of knowledge with in-built time-bound competitions between students; lesson plans which help streamline teaching and create an engaging learning experience. DIKSHA is a giant storehouse with 3,500 or more energized textbooks, 150,000 eContents, 2685 eCourses with over 60 million daily page hits. The energised textbook solution allows educational boards to achieve access to digital content through QR codes printed in textbooks. E-content on DIKSHA is available in 31 Indian languages.

Country: Nigeria
Title: Online portal for the Education Sector COVID-19 Response Strategy
Implementer: Ministry of Education
Short description: The Ministry of Education has developed a COVID-19 Education Sector Strategy and updated its online Portal for the sharing of resources across the country. This has enabled other states to adapt and develop their state specific strategies and importantly commenced messaging on prevention and containment of COVID-19 as well as using the radio to broadcast lessons. At least 33 out of 36 states began radio programmes in their states with support from development partners. Development Partners made available resources to the Federal Ministry of Education and States to encourage and support continuity of education and technical assistance to readapt existing curriculum for radio diffusion. UNESCO made available the McKinsey toolkit, Framework for school reopening, the Girls back to school strategy and learning contents developed from projects such as the School Meets the Learner Approach (SMLA) among other resources. UNICEF is the coordinating agent for the GPE Accelerated Fund. Though this is just for the 3 most hit northeast States, Borno, Adamawa and Yobe (BAY) States, the project is procuring ICT equipment, desktops and distributing books to those without access to digital technology. The World Bank through its Better Education Service Delivery for All is working on re-purposing financing to address the Education COVID-19 response. In Edo State, the Edo-BEST@Home is a mobile-based remote learning programme that extends the pre-existing Edo Basic Education Sector Transformation (Edo-BEST) programme, a Public-Private Partnership (PPP) between the Edo State Basic Education Board, the World Bank, and Bridge International Academies.

I.1.5 Adapting teacher roles to hybrid learning

Country: Estonia
Title: Tiigrihüpe (Tiger Leap)
Implementer: Ministry of Education
Short description: Support to teachers to adapt their roles towards hybrid learning is embedded in the countries historical efforts to leverage technology for teaching and learning in the 1990s and the vigorous modernization of its educational system, using information technology for the benefit of social development. During the early lockdown period, a team of university-trained "educational technologists" who are based in schools worked with teachers to ensure the best use of digital resources. A further key advantage was that teachers and school leaders in Estonia are already used to working as designers of innovative learning environments, and have great flexibility on how to best configure the people, the spaces, the technology and times in their respective context. As a result, teachers at schools were able to reach out immediately to almost all children and learning loss has reportedly been minimal.

Country: Nicaragua
Title: Aulas Digitales Móviles (Mobile Digital Classrooms strategy)
Implementer: Ministry of Education
Short description: As part of the implementation of the updated Mobile Digital Classrooms strategy (Aulas Digitales Móviles)[2], the project includes a socio-emotional support programme targeting school staff, students and their families. There are three main components: i) guidelines and manuals for school principals and teachers on how to promote self-care, provide socioemotional support to families, and develop socioemotional skills through school activities (including principals and teachers' support and training); ii) student support, and iii) parent support. The World Bank is also supporting the government through: (i) strengthening access to WASH facilities in schools located in remote areas through cost-effective water and sanitation facilities, and (ii) pedagogical guides with prioritized content to accelerate learning for vulnerable groups with low or no access to digital technologies.

Country: Peru
Title: Aprendo en Casa (I learn at Home)
Implementer: Ministry of Education (MINEDU)
Short description: When MINEDU started implementing *Aprendo en Casa*, teachers received guidelines that stressed the importance of observing learning sessions through the channel of their preference, communicating with students and parents, subscribing to online learning courses through PeruEduca, among other activities (see resources section). In addition, Regional Directions of Education (DRE) elaborated complementary guidelines to accompany what MINEDU had developed, and Local Education Units (UGEL) in turn designed complementary guidelines to accompany what the Regional Directions of Education (DRE) had produced. For example, the local education unit in Lambayeque, a region located in the north of Peru, requested teachers to submit daily reports of their remote work with students. Moreover, on 21 May 2020, MINEDU published additional requirements: teachers needed to submit a monthly report with evidence of their remote work and had until the end of May to submit reports from March and April. This whole 'support system' ended up generating teacher burnout and discontent. Peru's national teachers' union (SUTEP) submitted a formal complaint on 27 May 2020. After listening to teachers' feedback, MINEDU reacted quickly

2 To increase access to digital learning contents for vulnerable students in 80 primary rural schools with no or limited connectivity.

and adjusted the guidelines and requirements on 29 May 2020, to reduce administrative workload.

Country: Ukraine
Title: Virtual EdCamps
Implementer: EdCamp Foundation
Short description: Virtual EdCamps are online conferences that promote peer-to-peer learning among teachers. Launched in 2010, they are built on the idea that teachers can learn from and inspire one another to enhance their professional skills with the goal of improving student outcomes. Edcamps adopt the "unconference" model where sessions are organized, structured, and led by the people attending the event. They are viewed as cost-effective, scalable, and easily replicable. In response to the COVID-19 pandemic, many Edcamps have been hosted entirely online to support the new and urgent needs of educators. Edcamp Ukraine successfully hosted the online Edcamp, "High Five for Education" on 13-20 April 2020. With support from Digital Promise, an NGO in the United States, over 10,000 teachers from Ukraine, Belarus, Georgia, Armenia, and Moldova attended sessions spanning 5 days. The participants themselves selected the sessions they wished to attend, and volunteer participants moderated each of the breakout rooms on the videoconference platform. Post-event surveys revealed that participants found the content useful, and enjoyed the interactive nature of the sessions, the content, and the ability to interact with their professional peers. They also appreciated the convenience of being able to participate from the comfort of their homes.

Country: Uruguay
Title: The Ceibal Plan
Implementer: Ministry of Education
Short description: The COVID-19 pandemic reinforced the demand for innovative effort in equipping teachers and pedagogical leaders in Uruguay to underpin digital readiness and pedagogical continuity. The Ceibal Plan, in articulation with the National Public Education Administration, was introduced to address teachers' needs to adjust to remote and blended teaching for early childhood, primary and secondary education levels, changing classroom conditions and diverse household settings with unequal access to technology. It was also meant to present engaging content for teachers and students to help cope with constrained in-person interactions. The *Ceibal en casa* [Ceibal at Home] programme has helped teachers and learners to use combined or alternative use of low tech and digital media, with audio-visual and digital storytelling.

I.1.6 Application of skills development frameworks

Country: France
Title: Pix - Cultivez vos compétences numériques
Implementer: Ministry of Education
Short description: PIX is an online platform developed in 2016 that assesses and certifies digital competences based on DigComp. Any French speaker can assess his or her skills using a performance-based assessment. Even though Pix is currently only available in French, it is constructed on an open-source platform that can be adapted to different languages, frameworks or skillsets. At the end of the test, the person receives a digital skills profile with targeted recommendations for future learning and can be officially certified by taking a test under strict examination conditions. Employers and schools can also create accounts to coordinate assessment of employees' and students' digital skills. By 2020, Pix will replace the current secondary school Internet certificate.

Country: **Sub-Saharan Africa - Benin, Burkina Faso, Morocco, Rwanda, Tunisia**
Title: The Smart Africa Digital Academy (SADA)
Implementer: **National ministries of education**
Short description: SADA's implementation across the 32 member states of Smart Africa is expected to contribute to the SDG4.4, with a significant increase in the digital skills readiness index of the entire continent by 2030. Its concrete implementation across the continent comprises several activities in a phased approach : (i) Identify and promote global, regional and national digital skills initiatives across member states; (ii) Define a digital literacy framework for the African continent; (iii) Conduct executive digital skills capacity building programmes for senior level policy makers in collaboration with relevant stakeholders. SADA is currently supporting the development of an inclusive digital literacy framework for Africa that will promote and measure the safe use of digital technologies to access information, communication, e-Governance services, job skills, learning, financial or eHealth services. This framework will endorse inclusion of vulnerable populations and encompass the various inequalities within the African digital contexts (such as low access, low awareness, low literacy and low infrastructure) and variations in access, core literacy levels, or perceived value of digital technologies.

I.1.7 System level interventions and systems strengthening

Country: **Canada (Ontario)**
Title: Policy/Programme Memorandum No. 164: Requirements for Remote Learning
Implementer: **Ministry of Education**
Short description: Students in Ontario have been learning through mail and radio since the 1920s, and then, as technology progressed, through combinations of video conferencing and online learning. Throughout this time, remote learning has been publicly governed by school boards and the provincial government. Curriculum was developed by experts and went through a thorough process of evaluation and consultation. This longstanding method of delivering online learning is about to undergo a radical change. It is the firm belief of school boards that e-Learning courses delivered through local schools, or collaboratively across a school district(s), where teachers know their students' learning needs, is a far superior model of delivery (The Ontario Public School Board Association, December 2020).

With this in mind, the province introduced Policy/Programme Memorandum No. 164: Requirements for Remote Learning during spring 2021 to make remote learning a permanent part of Ontario's education system, and to change the way it is governed. Among other things the planned legislation will:

- Require school boards to permanently offer synchronous, remote learning in elementary and secondary schools for any student.

- Require boards to offer synchronous online learning when schools are closed for emergencies or snow days.

Create new regulatory authorities to:

- Prescribe (dictate rules governing) the roles and responsibilities of school boards, school authorities, and other entities to be prescribed in regulation[ii] (e.g., TVO, TFO, trustees' associations, the Consortium d'apprentissage virtuel de langue française de l'Ontario, consortia) in the delivery and coordination of online and remote learning.

- Make decisions on things like the software, information systems and/or technology-based instructional tools and resources that will be used to support online learning and data sharing processes.

- Establish data-sharing processes that enable an effective online learning system

The new legislation institutionalises the shift in control over online courses from school boards to the school level and sets the stage for the Ministry to make regulatory changes under the Ontario College of Teachers Act, making it mandatory that initial teacher education programmes cover instructional pedagogy in an online environment. Under the new system, school boards will still have some input into the kinds of courses offered online, but TVO/TFO will be responsible for developing the content for online courses and for maintaining the course catalogue that students will access centrally.

Country: **Canada (Manitoba)**
Title: [Manitoba Remote Learning Support Centre (RLSC)]
Implementer: **Ministry of Education**
Short description: The Manitoba Remote Learning Support Centre (RLSC) and InformNet ensure continuity of learning, build capacity, and aim to achieve greater consistency, and support educators in providing effective online learning. The plan includes:

- the development of a Remote Learning Framework to outline guiding principles to help build common understanding and support evidence-based practices for online learning and teaching

- the development of Education Remote Learning Standards to ensure consistent application of remote learning programming across Manitoba during the COVID -19 pandemic

- the launch of an RLSC to underpin system-wide remote learning from kindergarten to grade 8 for students learning from home as well as students and families who have registered for home-schooling in response to the COVID-19 pandemic the expansion of InformNet (an online teacher-directed learning option for grades 9 to 12).

This enables an improved distance learning experience for students throughout Manitoba. In addition, in order to benefit students with no or low internet connectivity, funding for the Teacher Mediated Option, for grades 9-12 with a grades 5-8 pilot, has been expanded (see www.edu.gov.mb.ca/k12/dl/learning_opportunities.html).

Country: **Nigeria**
Title: [Edo-BEST database]
Implementer: **Ministry of Education**
Short description: Since 2018, the Edo-BEST programme, with the support of its more than 11,000 teachers across the 900 schools that it operates, has been building a database with the profile and contact information of every student. With this information, teachers were able to contact parents as soon as the government announced school building closures, to inform them of classroom developments, to maintain personal contact, deliver learning materials, and provide remote support to ensure that children continued learning while school buildings were not open. Automated assessments are also a part of EdoBEST's efforts to fostering effective use of digital technologies and learning during the pandemic. Students can access interactive quizzes through mobile phones on a daily basis. Quizzes are effective to help

students to practice, retain what they learned that day for each course, and receive instant automated feedback through WhatsApp or a text message. All quizzes are also aligned to the Edo state curriculum, the education level, and allow students to practice a wide range of skills, from using vocabulary to solving math equations.

Country: **Pakistan**
Title: [M&E framework for pilot blended learning programme]
Implementer: **EdTech Hub worked with the Ministry of Federal Education and Professional Training (MoFEPT)**
Short description: In late 2020, MoFEPT is working with EdTech hub to develop an M&E framework for a pilot of a blended learning programme. The partnership between technical experts and the Ministry resulted in a robust framework covering a comprehensive set of indicators, and laid the foundation for its implementation (Khalayleh et al. 2021). The M&E framework is fit-for-purpose and contextualized to Pakistan; to ensure buy-in and local ownership among stakeholders; to ensure local capacity to further refine the framework as needed; and to assess the impact of the pilot.

As part of the development process, the EdTech Hub and the MoFEPT spent two months collaborating on the ideation and design of an M&E framework for a blended learning pilot programme in Islamabad. The framework is holistic and encompasses 17 separate indicators spread across the following components: infrastructure and access; learning materials; teacher training; instructional practices; improved quality of learning; teacher support network; and parental engagement.

The initial framework has been finalized and the MoFEPT is responsible for its operationalisation and implementation.

- Designing a M&E framework for blended learning must be aligned to the specific context in which it is used and responsive to the goals of the specific initiative or programme.

- Designing and implementing the framework is an iterative process, and the framework should be something that is continuously refined and improved upon based on the data and feedback collected.

This model of collaboration, its process, and the resulting framework is intended as a global public good and can serve as an example for other countries preparing to undertake similar M&E planning.

Country: **Peru**
Title: **M&E system for** [Aprendo en Casa]
Implementer: **MINEDU's Monitoring and Evaluation Unit, with the support of Innovations for Poverty Action (IPA)**
Short description: MINEDU's Monitoring and Evaluation Unit has begun monitoring levels of adoption and satisfaction of the *Aprendo en Casa* with principals, teachers, and families through phone calls once a month (information from principals was only gathered during the first month). This effort started just one week after the strategy was launched. More than 37 thousand members of the education system have been surveyed between mid-April and early-June of 2020. Phone calls gathered data related to *Aprendo en Casa's* reach, channels used by students to access remote learning and support from teachers to students, among other information. Information gathered is based on representative samples. Results of the monitoring process are readily available for anyone to access through an interactive site, ensuring transparency. As of July 2020, data is available for April, May, and June 2020.

I.1.8 Financing: sources and investments

- Government funding earmarked or diverted to support remote and hybrid learning

Country: **Canada (New Foundland and Labrador)**
Title: **Purchase of equipment for lower and upper secondary level**
Implementer: **Provincial government**
Short description: The Newfoundland and Labrador provincial government has invested $20 million in the purchase of laptops for all teachers and students in lower and upper secondary throughout the K-12 education system. Devices were distributed as soon as they became available through a public procurement process. The investment ensures equal access to education so that each student, regardless of their ability, where they live or their socio-economic status, can continue learning outside the classroom, while providing teachers with the tools they need to provide distance education effectively. The project is part of efforts to modernize the K-12 system towards a true digital learning environment.

Country: **Federal Republic of Germany**
Title: Digitalpakt Schule
Implementer: **Federal government**
Short description: Not all parents are able to buy their children a mobile device for digital learning at home. A federal investment initiative is strengthening the *'Digitalpakt Schule'* ensuring that all pupils have access to distance learning through the necessary digital devices. The Federal government (on the basis of the coalition committee) provides 500 million euros, and the Länder 50 million euros, for students who do not have learning devices at home. The Länder are supervising the practical implementation of the initiative (procurement processes, device setup, additional equipment, etc.). The initiative will be fully implemented by the end of 2021.

Country: **France**
Title: Digital Education Regions **(Les territoires numériques éducatifs)**
Implementer: **Government in collaboration with local Préfectures and the Orange Foundation**
Short description: Launched in two French local authorities in September 2020 (EUR27.3million for Aisne and Val-d'Oise) and extended to 10 more departments in September 2021 through a funding programme "For the Future", the Digital Education Regions (*Les territoires numériques* éducatifs) offer digital training and equipment adapted to the local needs and contexts so as to: improve educational performance through an integrated, proactive digital policy: run training programmes for teachers and parents; make digital teaching resources and equipment available (to pupils, classes, resource centres, teachers); measure the impact of mastering digital education on the professional actions of teachers and on pupils' learning. In order to make distance teaching and learning easier, "digital" kits have been given to students, teachers and schools participating in the project. These will make it possible to implement educational scenarios and hold special events when used in classrooms. Sustainability issues have not been forgotten as 700 refurbished computers were used in the first phase of the scheme.

Country: **United Kingdom of Great Britain and Northern Ireland**
Title: Get Help with Technology programme
Implementer: **National government**
Short description: In England, through the Get Help with Technology programme, more than GBP 400 million has been invested in ensuring access to remote learning and online social care since the pandemic began for primary and secondary schools (years 3-11), academies, colleges (years 12-13) and other institutions of further education (FE).

This includes the provision of over 1.3 million laptops and tablets to schools, trusts and local authorities for use by disadvantaged learners and young people. Over 100,000 families in England have also received support to get online through uplifts in mobile data and 4G wireless routers. Work has also been undertaken to ensure that every school has access to free and effective technical support to set up on Google for Education, or Microsoft Office 365 Education, offering peer-to-peer training and support from schools and colleges leading the way with the use of technology and, working alongside the Department for Digital, Culture, Media & Sport, to accelerate the roll-out of full fibre internet connectivity to schools.

In Wales, the Government of the United Kingdom announced a £15 million investment in education technology in Welsh schools for the next academic year. The investment is the continuation of the Hwb EdTech programme, which has already seen an investment of over £92 million by the Welsh Government over the last two years, and will further support the transformation of digital infrastructure of all maintained schools in Wales. Funding will also be used to ensure ongoing MiFi connectivity for digitally excluded learners, to the end of the current school year in July. So far, the Hwb EdTech programme has: i) provided over 128,000 devices since the start of the pandemic, with another 54,000 being delivered in the coming weeks; ii) funded software which has allowed around 10,000 re-purposed devices to be issued to 'digitally excluded' learners; iii) provided 10,848 MiFi devices for learners without internet access at home; iv) enabled local authorities to purchase over 300,000 digital infrastructure products, including cabling, switches and WiFi devices.

- Partnerships with telecoms providers

Country: Australia
Title: Mobile Black Spot Programme
Implementer: Australian government
Short description: The Government has committed $380 million to the Mobile Black Spot Programme to invest in telecommunications infrastructure to improve mobile coverage and competition across Australia. Funds are offered to telecoms providers on a competitive basis to address broadband and mobile telephone black spots and gaps in service provision. It mainly focuses on geographical areas where communities benefit most, such as economic hubs, emergency service facilities, health clinics, schools, indigenous community centres and local government sites. Investment resulted in $836 million in investments through co-contributions from local state territory governments of mobile network operators, and community organizations and led to instalment of 1,200 new base stations across Australia (Australian Government, 2021).

Country: Rwanda
Title: Extension of network infrastructure
Implementer: Public private partnership
Short description: An example of an existing public-private partnership is that between the government of Rwanda and KT Corp of South Korea to expand the 4G network that covers more than 95% of the country. KT Corps was responsible for building the backbone of the new telecommunication network. In addition, the company is responsible for network operations. While KT Corp brings in expertise and staged cash injections, the Rwandan government's equity investment in the joint venture included the assignment of its 3,000 km national fibre optic network assets, spectrum, and a wholesale-only operator license. In addition, further financing was arranged by debt & vendor sourcing. An

extension of this model, or a similar new SPV to serve schools, could make a lot of sense in Rwanda.

Country: **Canada**
Title: **Extension of network infrastructure, spectrum and operations into rural areas**
Implementer: **Public private partnership**
Short description: Since 2000, TELUS, the Canadian 5G and telecom provider, has invested almost $240 billion in network infrastructure, spectrum and operations to enhance the coverage, speed and reliability of its world-class network and connect customers from coast to coast to coast. Since the pandemic began, it has deepened efforts to expand its network into more rural and remote regions, noting that its 5G technology is now available in 81 cities and towns across the country and continuously expanding. This is helping to connect people regardless of their socio-economic status. In relation to education provision, TELUS Internet for Good partnered with school boards during the pandemic to expand the programme to families in need with students in Kindergarten through Grade 12. Internet for Good offers eligible low-income families in British, Columbia, Alberta and Quebec access to low-cost, high-speed internet.

Country: **United States of America**
Title: **Extension of mobile internet**
Implementer: **Public private partnership**
Short description: Ericsson has worked with Vermont Telephone (Vtel) to bring mobile internet to high school students in Rutland, a city where many families do not have sufficient broadband connectivity for remote learning. Ericsson expedited the delivery and installation of next-generation 4G/5G wireless radios and antennas on a building in downtown Rutland. VTel delivered wireless modems and routers to homes, allowing students to receive free Internet service immediately. It all happened in less than 10 days, helping local students get the most out of remote learning.

- Zero ratings policies

Country: **Colombia**
Title: Aprende Móvil (Colombia Learns Mobile)
Implementer: **Ministry of Education**
Short description: The initiative was created to mirror the "*Colombia Aprende*" ["Colombia Learns"] portal, the main site used by the Ministry of Education to support education continuity during school closures. This agreement between the Ministries and the mobile operators ensures that data related to the Colombia Aprende will be charged a zero tariff. The initiative now facilitates connectivity access to teachers, parents and students (from Early Childhood Education to Secondary Education) in rural and urban areas throughout Colombia. The service is enabled for mobile phone users (voice and data) in both the pre-paid modality and post-paid modality up to 71 214 Colombian pesos or approximately USD 20 (two Tax Value Units, or Unidad de Valor Tributario). Its success has been due to a close collaboration between the Ministry of Education and the Ministry of Information Technology and Communications (MinTIC). To generalize and enforce this policy, Decree 555 of April 15, 2020 was introduced, paving the way for a free mobile navigation tool for mobile phone service users.

Country: **South Africa**
Title: **Agreement to reduce connectivity and data costs**
Implementer: **Ministry of education in partnership with mobile network operators MTN, Cell C, Telkom and Vodacom**
Short description: Mobile network operators MTN, Cell C, Telkom and Vodacom came on board in the first days after schools closed in March 2020 and contributed to learning

continuity by zero-rating[3] many education sites to reduce data costs for families whose children needed to access online learning. It is interesting to note that, a few days into the lock down, data traffic surged between 35% and 60%, was reported in almost all local networks. The government still noted with concern however that, even though mobile network operators in the country had started to drop data costs, many people were unable to access the rich content that had been made available, due to issues of broadband access or network capacity. Poverty also limits access, and thousands of pupils were still not able to continue their schooling through online learning. The government indicated that electronic readers would be available via all platforms of major cell phone networks in South Africa, i.e., Vodacom, MTN, Telkom, and Cell-C, as well as a freely downloadable educational platform with more than 2000 electronic readers in the indigenous languages of the country. The government also indicated that they would also promote the African Storybook series through the 2Enable App.

- Use of universal service funds

Country: **Morocco**
Title: Bringing Digital Devices and Broadband to Teachers' (NAFID@programme)
Implementer: Ministry of Education
Short description: Funding for Morocco's USF comes from telecommunications operators that provide 2 percent of their turnover before tax. The funds have largely been focused on the education system, including specific programmes for schools and to equip multimedia centres at schools around the country.

One notable example is the 'Bringing Digital Devices and Broadband to Teachers' (NAFID@ programme). The programme seeks to enhance teachers' ICT-related skills and to provide localized computer content and training to help teachers integrate ICT in their classrooms. Nearly half the teachers in Morocco have purchased 50,000 laptops at a subsidized price, with localized, built-in content. More than 150,000 teachers have also subscribed to a subsidized broadband Internet connection.

As part of its 2018-2028 action plan, the Mohammed VI Foundation for the Promotion of Social Work of Education-Training gave, on June 9, 2021, the kick-off to the 2nd edition of the Nafida@programme to promote family access to information and communication technologies. The Nafida 2 programme is intended for all Foundation members, active and retired, in the public education-training sector; and who are in regular membership. It is implemented by:

- The granting of individuals subsidies of up to 2,000 dirhams for the purchase of a laptop or desktop computer up to a limit of 150,000 members, according to the "first come, first served" rule.

- The 25% reduction on public subscription prices for broadband internet connection: 4G and optical fibre, with the 3 telecom operators operating on the national market, namely Orange, Maroc Telecom and inwi.

Country: **Pakistan**
Title: ICTs for Girls project
Implementer: Ministry of Information Technology in collaboration with the Ministry of Education
Short description: The Universal Service Fund (established by the Ministry of Information Technology) is spreading the benefits of ICT

3 Legislation in South Africa for zero-rate educational content has its historical basis in the Disaster Management Act 57 of 2002: https://openbylaws.org.za/za/act/gn/2020/651/eng/

revolution to all corners of Pakistan. The aim of the "ICTs for Girls" project, in particular, is to increase girls' access to ICT infrastructure, the latest hardware, high speed Internet, software and trained human resource to support their employability. Under the umbrella of this project, the Ministry of IT & Telecom is overseeing the following two project components:

- *Establishment of Computer Labs in Women Empowerment Centres*: Under this project 144 Women Empowerment centres and other educational institutions have been provided with ICT Model Labs. Women empowerment centres is an initiative of Pakistan Bait-ul-Mal devoted to capacity building of women in un-served and underserved areas of Pakistan. Through this programme, over 15,000 girls will be trained annually at state of the art computer labs under the coaching and training programme of Microsoft.

- *Establishment of Computer Labs in Government Girls Institutions of Islamabad Capital Territory*: Under this project 226 Schools of Islamabad have been provided with ICT Model Labs. In addition to the equipment, 202 teachers have also been placed at these institutions. These teachers have been trained by Microsoft under Train the Trainer programme on 21st Century Super Skills. This project will help in making over 110,000 girl students "Computer Literate" studying in Islamabad's schools and bring them at par with students elsewhere in the world.

In collaboration with Microsoft, teachers are primarily trained in coding, computing, coaching and communication, or Super Skills for 21st century, in addition to the technical domains i.e. cloud computing, web designing, coding, introduction to databases, basic computer programming, basics of software design and development. An ICT for Girls website has also been established to allow collaboration and learning opportunities to the beneficiaries.

Country: **United States of America**
Title: **e-rate programme**
Implementer: **Federal government**
Short description: The most famous, and prototypical, example of how a 'universal service fund' has been used to connect schools to the Internet is the e-rate programme in the United States. The Programme provides subsidies for eligible elementary and secondary schools and classrooms, as well as libraries, for internet access, internal network connections, and telecommunications services. It is a consequence of the U.S. Telecommunications Act of 1996, the Universal Service Fund was established in 1997 to facilitate the deployment and adoption of fixed and mobile telecommunications and broadband services. The e-rate programme has, over the course of almost twenty years, helped to raise the number of schools with Internet connections from 14 percent to 100 percent today.

The Federal Communications Commission (FCC) is responsible for establishing USF policies and oversees the Universal Service Administrative Company (USAC), an independent not-for-profit organization tasked with administering the USF. It has taken recent steps to expand and modify three of the USF programmes to address the growing connectivity needs and challenges facing Americans during the COVID-19 pandemic: the Lifeline Programme; the Schools and Libraries (E-Rate) Programme; and the Rural Health Care Programme. The steps include the temporary lifting or suspension of programme rules, the modification of programme requirements, the issuance of temporary waivers, and the increase of budgets. The FCC also waived gift rules, until September 30, 2020, to enable schools and libraries to solicit for and accept improved connections and additional equipment and devices and reiterated that schools and libraries that are closed during the pandemic are permitted to allow general public use of E-Rate supported Wi-Fi networks while on school and library property.

There is now a growing pressure to further modify ERate Programme rules to support home broadband access for school-aged children, but some, including FCC Chairman Pai, question whether the FCC has the authority to use the programme to subsidize such services outside the classroom. The FCC has not, to date, taken steps to modify the programme to expand connection subsidies beyond eligible schools and libraries.

- Grants, data packages, subsidies, vouchers and scholarships for vulnerable and at-risk learners and teachers

Country: **Dominican Republic**
Title: **The Bono Estudia Contigo [I Study with You Scholarship]**
Implementer: **Ministry of education**
Short description: The Bono Estudio Contigo [I Study with You Scholarship] targets financial support (through a voucher based scheme) for the most-at-risk higher education students (university, technical or master's degree students from some private universities) and has so far partially subsidized the enrolment costs of 30,000 low-income students. This is an extraordinary plan of financial aid enabling students to re-enrol and to reduce university dropout. Those students who have not been able to return to class due to loss of means are identified and the study centres receive the list with the beneficiaries. This list is published on the web portals of the universities as well as that of the Ministry of Higher Education, Science and Technology (MESCyT), in order to be consulted by users.

The Estudio Contigo voucher can only be used to pay for re-enrolment, and will be disbursed to universities once students complete the re-entry process. The voucher will be divided into items of 1,500 pesos for each of the four months of the academic period. This initiative has the support and participation of the Progresando con Solidaridad (Prosoli) programme; Dominican Association of University Rectors (ADRU); Unique System of Beneficiaries (Siuben), and the Dominican Association of Universities (ADOU).

Country: **Latin America**
Title: **Digital devices for teachers**
Implementer: **Ministries of education**
Short description: With regard to provision of digital devices for teachers, and as part of the process of digitalizing education in El Salvador, work is underway to acquire digital equipment for 100% of pupils and teachers in public education (Ministry of Education of El Salvador, 2020b). In Argentina, there are proposals to offer loans from Banco de la Nación Argentina at a subsidized rate to enable teachers to buy computers (Molina, 2020). In Paraguay, although no equipment has been distributed directly to teachers, priority was given to the delivery of 2,500 laptops with Internet access to 504 educational institutions in indigenous communities.

Country: Turkey
Title: **Providing computer equipment**
Implementer: **Ministry of Education**
Short description: Since the onset of the pandemic, the Ministry of Education and NGO partners have delivered 500,000 tablet computers to students with no computer or internet at home, students with special education needs, families with numerous children of school age and low income levels. Each tablet is provided with a 4.5G GSM SIM card and has a monthly 25 GB data package to be used for the online learning platform (EBA). EBA was greatly expanded during the pandemic, providing remote education for over 18 million Turkish students. To support students without internet access, the government set up EBA Support Points across the country to enable access to the more than 1,800 courses offered online while the government continued its delivery of devices.

- Community cost sharing

Country: South Africa
Title: Zenzeleni Network
Implementer: **Community and commercial providers**
Short description: The country has successfully set-up several community-led initiatives, though most of the country's connectivity is still provided by commercial parties. One example is the Zenzeleni Network. Zenzeleni (which means "Do it yourself" in Xhosa) is a community-owned wireless internet service provider based in rural South Africa. Its model aims to significantly cut costs of telecommunications, retain expenditure within communities as a form of social entrepreneurship, and support the development of a rural digital ecosystem towards bridging the digital divide.

Born in 2012 through a partnership between the University of the Western Cape (UWC) and the local tribal authority of the Mankosi community, the Zenzeleni Network uses solar energy technologies to power high-speed internet and mobile charging stations for more than 13,000 members of the local community. The network can respond flexibly to self-defined needs and community members welcome its expansion to other villages.

Country: Spain
Title: Guifi.net
Implementer: **Community and commercial providers**
Short description: Another successful, large-scale project (in a developed market) is Guifi.net in Spain. Guifi.net is a free, open, and neutral, mostly wireless community network, with over 35,000 active nodes and about 63,000 km of wireless links. The community-based expansion treats network connectivity as a common good, democratizing ownership of components between individuals, local commercial partners, municipalities, corporations, and the network itself. Such partnerships enable Guifi.net to reach many rural areas of Catalonia that other networks failed to access, finding cost-effective ways of connecting buildings with fibre by using existing infrastructure, such as water or sewage pipes. This bottom-up initiative is growing in other parts of the world with the objective of common governance of networks.

I.1.9 Inter-sectoral and multi-stakeholder partnerships

Country: **Federal Republic of Brazil**
Title: National Teaching and Research Network (RNP)
Implementer: **University**
Short description: The Rede Nacional de Ensino e Pesquisa (RNP) is the Brazilian advanced network infrastructure for collaboration and communication in teaching and research. It connects more than 250 Brazilian institutions with each other and abroad, making the interaction between people and resources viable through advanced applications. In addition to interconnecting all federal institutions of higher education and research, this infrastructure, called the Ipê network, provides a laboratory for the development of new applications and network services for the benefit of its user organizations. Its funding comes from the Brazilian government through the Ministries of Education (MEC), Science, Technology, and Innovations (MCTI), Health (MS), Defence (MD), and Citizenship (MC). The maintenance of the Ipê network is carried out by the Inter-ministerial Programme of the ministries of Education and Science and Technology, through the management contract of the RNP Association Social Organization (RNP-OS) with the Ministry of Science and Technology. In addition to having public resources, the RNP collects private resources through projects with computer companies and other organizations. Currently, RNP provides connectivity through its own network to around 1,500 sites throughout Brazil, serving an estimated 4 million users. RNP has recently launched Northeast Connected, a PPP to install thousands of kilometres of optical fibre and connect the cities in six states in the North East. This is a partnership with ISPs to build metro networks, and with Power Distribution companies to provide pairs of idle optical fibres on transmission lines, leading to cost savings of ~ $38m. In Brazil, a PPP of RNP, together with the Ministry of Education (and other relevant ministries) would therefore be considered a suitable operating model in Brazil.

Country: **Federal Republic of Germany**
Title: STEM-Alliance 'We stay smart'
Implementer: **Federal Ministry of Education and Research (BMBF) and the STEM working group**
Short description: In the spring of 2020, the German Federal Ministry of Education and Research (BMBF) began a national campaign to form alliances to offer remote STEM learning experiences during lockdowns. The MINT-Allianz '*Wir bleiben schlau*', STEM-Alliance [We stay smart] has joined together more than 90 STEM actors and the number of digital courses on offer have been steadily growing. The content ranges from podcasts and puzzles to formal programmes and tutorials, representing a range of digital learning offers to encourage creative learning, experimentation, and coding from home.

Country: **Malaysia**
Title: Wawasan Open University
Implementer: **University**
Short description: Wawasan is a private university that offers many part-time courses for adults at undergraduate (including 11 full-time bachelor degree programs) and graduate levels. With a main campus and six regional centres to support its distance learners, it is a great example of hybrid learning that integrates in-person support with Open Distance Learning (ODL) to expand access to higher education opportunities among all Malaysians.

Wawasan Open University (Malaysia) case has underlined that there are different models for financing content development and use including: using proprietary course materials under license, producing stand-alone materials, and developing Open Education Resources under the "wrap around textbook model."[4] Massive Open Online Courses (MOOCs) that are generated by universities are also recognized and approved by the Ministry of Higher Education and the Malaysian Qualifications Agency (MQA) offering programme credibility that many commercial suppliers of MOOCs cannot.

Country: Peru
Title: Aprendo en Casa (I Learn at home)
Implementer: Ministry of education in partnership with different actors
Short description: Peru's school year runs from mid-March to mid-December. Everything was ready for the onset of this on 16 March 2020; but instead, the President announced a strict lockdown. Peru's Ministry of Education (MINEDU), with support from NGOs, technology companies, telecommunication operators, and broadcasters launched a multichannel remote learning initiative to mitigate learning loss as a result of school closures.

It is noteworthy that MINEDU planned, developed and launched a comprehensive multimodal strategy to deliver remote learning at scale in just 12 days. The entire programme aligns to Peru's national curriculum and has been designed to provide remote education through four channels: television, radio, web and printed material. In spite of its commendable speed of conception, the strategy still had to overcome certain key challenges. These included (i) reaching students who live in rural areas in the middle of the pandemic, (ii) building new content and a delivery platform, (iii) sustaining student engagement, and (iv) providing guidance to teachers while avoiding burnout. MINEDU also had to deliver quality educational resources to all students in a country where household access to these is highly unequal: for example, while almost 99 percent of urban homes have access to electricity, only 69 percent of rural ones do (UNICEF data). Approximately 85 percent of households also possess a TV, 84 percent a radio, 82 percent a mobile, and only 24 percent have connection to the Internet at home (data from UNICEF Peru: *Aprendo en Casa* [I Learn at Home]. Meanwhile, although MINEDU curated existing learning material, most of the content and platforms had to be developed from scratch. MINEDU's officials needed to come up with innovative solutions for this challenge within a short timeframe made more complex by a strict lockdown in the country.

MINEDU leveraged existing resources and engaged various stakeholders to build a multimodal remote learning solution that could be rapidly scaled up to a national level. The ministry officials mobilized and developed resources in three key components of the remote learning strategy: (i) infrastructure and connectivity (addressed in chapter 2), (ii) content, and (iii) delivery platforms. A large pedagogical team at MINEDU organised already existing content, which consisted of mainly educational videos and digital workbooks. This team also curated external content that third party organizations such as Plaza Sesamo (Mexico) and Paka Paka (Argentina) agreed to share for free with *Aprendo en Casa*. However, most content was created from scratch by a large team of pedagogical experts from MINEDU's department of Basic Education. Since mid-March, this team has developed lesson plans and scripts as well as coordinated the production for *Aprendo en Casa*'s multimodal strategy.

4 (Miao, Mishra, & McGrea, 2016)

To deliver the content, MINEDU leveraged on existing partnerships with TV Peru and Radio Nacional, the government's television and radio platforms. The main private open signal television channels have also collaborated with this effort in transmitting learning sessions for the last years of secondary education. With the support of Regional Directions of Education (DRE) and Local Education Units (UGEL), new partnerships have been developed with over 1,100 local radios to reach remote communities. Although the ministry already had PeruEduca, an online training and content repository platform, MINEDU's department of Educational Technology decided to develop a mobile-responsive digital platform from scratch to deliver *Aprendo en Casa* content at scale.

This new platform can support an unlimited number of users at the same time and is "web-light" so that users can access its resources even in areas with low bandwidth. MINEDU's officials also analysed and later partnered with more than 60 mobile applications to allow teachers and students access to free resources related to communication, class management, digital libraries, content management and online learning, among others.

Country: **South Africa**
Title: **Africa Storybook Initiative**
Implementer:
Short description: Aimed at improving childhood literacy, the African Storybook Initiative was launched in 2014 to provide open access to digital picture storybooks in over 222 African dialects. The initiative is supported by private and foundation-funding to develop, publish, and use storybooks that can be read online or offline for free or downloaded and printed.[5] Once the platform was established, gathering, curating and translating stories incurs minimal costs.[6] Available as both a webpage and mobile app, the initiative allows users to read, use, guide, and make storybooks, adapting them to different reading levels and languages.

Country: **Uruguay**
Title: **The Ceibal Plan**
Implementer: **Strategic alliance between the public and private sector**
Short description: Named for a typical Uruguayan tree and flower called "ceibo", the Ceibal programme is Uruguay's one laptop per child initiative. The name is an acronym that stands for "*Conectividad Educativa de Informática Básica para el Aprendizaje en Línea*", or Basic Computing Educational Connectivity for Online Learning.

In collaboration with the British Council of the United Kingdom, "*Ceibal en Inglés*" (Ceibal in English) used hybrid learning models to solve the problem of lack of English teacher specialization in Uruguayan primary schools. To ensure the right of Uruguayans to second-language education, the programme consists of real-time videoconferencing between a remote English teacher and in-person primary school students and their classroom teacher. The lessons are accompanied by both digital and paper-based materials such as songs, videos, and games, which are explained by the remote teacher but distributed and overseen by the classroom teacher. The remote teacher and in-person teacher collaborate in half-hour virtual sessions to ensure that lessons are coherent and that teaching and learning styles are discussed and agreed upon. The classroom teacher is offered online English classes in advance of the hybrid teaching partnership, which are not

5 African Storybook, 2021

6 The total costs of a story benefitting thousands of early reading children can reach USD 1,450, once the platform has been developed (Welch & Glennie, 2016).

compulsory but may assist their in-person support of students during class periods.

The Ceibal programme has been spreading through the Ceibal Plan own channels, including social networks, LMS and its website, and through strategic alliances with the public and private sector. This includes Uruguay National Television (TNU), the National Public Education Administration and telecommunication companies, which facilitated access to digital content at no-cost or with limited charge. This helped to offer a variety of delivery platforms to address access inequalities, making training resources available to all teachers across the country. Additionally, Ceibal Foundation worked actively in the dissemination of this experience within a regional network of policy makers it coordinates, the Alliance for the Digitization of Education in Latin America (ADELA), funded by IDRC Canada. This innovation included sufficient flexibility for adaptation across contexts (urban and rural) and scalability at national level through Internet, television or audio contents.

I.2 Specific efforts to support readiness for hybrid learning

I.2.1 Systems readiness

Country: **Republic of Estonia**
Title: **Digital transformation of the education system**
Implementer: **Ministry of Education**
Short description: Long before the coronavirus pandemic, the government of Estonia had made the development of digital skills, high-speed internet and a sophisticated IT infrastructure a national priority. Today Estonia is one of the most digitized societies in the world, with a large number of public services available to citizen's online and broadband internet coverage across the majority of the country.

The ambitious *Tiigrihüpe* [Tiger Leap] programme, launched in 1997, was built on three pillars: (i) providing all schools with access to computers and the Internet; (ii) basic teacher training, and; (iii) native-language electronic course ware for general education institutions. Its aim was to build up its schools' technological infrastructure. To accompany, *Tiigrihüpe* Basic ICT courses for teachers were organized – in 1997 nearly 4000 teachers participated in the 40-hour computer basic training course, with thousands more in the next years. In 1999, new courses in electronic courseware, online information searches and preparation of educational materials were introduced. By 2001, Estonia had already met its first round of stated digital education goals.

Tiger Leap Plus, which followed the Tiger Leap programme, focused mainly on the ICT competences of students, teachers and educational staff. Its main activities included the creation of electronic educational materials, in-service training and support of teacher cooperation and experience exchanges. An educational portal known as School Life was launched in 2001, giving teachers opportunities to exchange ideas and ask for advice from colleagues, and allowing them to share good ideas, find educational materials, and discover useful links and electronic courseware information. Alongside the development of instructional and teaching material, teacher training was developed to accommodate this change. The priority was to create teacher trainers within the education community and to take the training as close to the participants as possible.

By 2004, teachers' computer use had diversified tutorial work and teachers' computer skills had significantly improved. Over the next decade, the range of courses diversified considerably and a network of teacher trainers was formed to provide courses all over the country. In 2012, two more important programmes for Estonian technology education were launched. The ProgeTiger programme has helped to improve technological literacy and digital competence of teachers and students. The programme provides children and youth with the skills they need to cope in the future. Robotics, programming, and STEAM subjects are very suitable for this as children learn to solve problems, to be creative, to collaborate, and to think critically.

The country's digital and IT readiness meant that schools slipped seamlessly into hybrid forms of teaching and learning when the first lock down occurred. Moreover, most Estonian schools were routinely using digital study materials including a platform of digital books called Opiq and electronic school management systems such as eKool, which connect pupils, parents and teachers. Students routinely have access to their own assigned iPads, centrally managed by schools and used to deliver and learn lessons, and were used to occasional online study days, where they worked from home rather than in the school building while their teachers were involved in other tasks.

Country: **United Kingdom of Great Britain and Northern Ireland (Wales)**
Title: **Digital transformation of the education system**
Implementer: **Ministry of Education**
Short description: In Wales, the Hwb EdTech programme has been in operation since 2012. It is the country's digital schools initiative providing broadband, digital infrastructure and now extending cloud services to all schools in Wales. Since its inception, the programme has supported schools and local authorities in upgrading their digital infrastructure, including the digital resources to support learners engaged in remote learning. More recent efforts have sought to ensure that all schools are working towards the Education Digital Standards.

In 2019, the Welsh government announced that local authorities in Wales were set to receive £50 million to upgrade Education Technology (EdTech) equipment within schools. The money would guarantee that schools are better equipped to embrace the changes brought about by the new Curriculum for Wales. The Welsh Minister for Education stated that this is about more than just buying new bits of kit. The programme would transform how local authorities and schools approach digital delivery, ensuring children are digitally prepared well into the future. The Hwb platform has played a crucial role during the difficult period of the pandemic, offering access to a wide range of bilingual digital resources to support the delivery of the curriculum for Wales, along with support for key areas such as keeping safe online and well-being. A further investment of £15 million helped to secure MiFi connectivity and software which has allowed schools and local authorities to provide the necessary technology to support digitally excluded learners remotely.

I.2.2 Teacher readiness

Country: **Rwanda**
Title: **Rwanda ICT Essentials for Teachers course**
Implementer: **Ministry of Education**
Short description: The Rwanda ICT Essentials for Teachers course is based on the UNESCO ICT Competency Framework for Teachers (ICT CFT). It draws from a set of competencies clustered around six major education focus areas that teachers need to integrate ICT into their professional practice and is based on a blended learning model with five days (42 hours) of face-to-face training and a further 40 hours are conducted online for a total of 82 notional hours. During the face-to-face training, teachers are exposed to the content and tools on the learning management system (LMS), and have an opportunity to work through some of the course content (units 1–6) with a mentor. Finally, the course material is composed of local course material and international Open Educational Resources (OER) which have been adapted to support the Rwandan context.

Country: **Spain**
Title: Aprendo en casa
Implementer: **Ministry of Education**
Short description: There are various support structures and initiatives in Spain to train teachers for the uptake of roles in hybrid classrooms and learning environments. The '*Aprendo en casa*' programme is designed to support teachers, educational staff, students and families with different types of digital resources, tools and training modalities for continuous professional development to deal with aspects relevant to the COVID-19 situation, including planning lessons for distance learning, navigating online platforms, and creating digital materials. A reference framework for digital competencies for educators has also been developed. Training can be carried out on INTEF courses (online tutored courses about eTwinning and on open massive online courses, MOOC, NOOC, SPOOC. More specifically professional development is offered for registered teachers by the eTwinning Central Support Service.
So far, the results have meant (in the training offered by INTEF) that (i) for the in-service training of teachers, 36 online tutored courses offered with 10,537 teachers participating; (ii) Initial training and open training: open massive online courses: 52,468 participants in 8 MOOC, 48 NOOC, 6 SPOOC and 28974 users in 15 Edu pills.

Country: **United States of America**
Title: Verizon Innovative Learning Teacher Training Pathways
Implementer: **Verizon and Digital Promise**
Short description: Since 2014, Verizon, a provider of communications technology, information, and entertainment products and services for consumers, businesses and government entities, has partnered with education non-profit Digital Promise to offer a device and up to four years of internet access to students and teachers at select under-resourced schools in the United States. Comprehensive professional development is offered to all educators in 511 schools to develop tools and strategies to effectively incorporate the technology into the learning experience.

In March 2020, as the Verizon Innovative Learning Schools moved into fully remote instruction, it quickly shifted its professional development offerings to a virtual model. In creating a virtual model, it was realized that there was a scalable delivery method and the opportunity to expand access to learning opportunities across the United States. Together with Digital Promise, Verizon launched the Teacher Training Pathways in October 2020, a free platform that delivers flexible, credentialed professional development to all U.S. K-12 educators. This new platform was designed to support educators with a focus on digital skills, remote learning and digital coaching.

The Teacher Training Pathways promote personalized learning for all educators nationwide and drove digital inclusion for K-12 education in the United States. At Verizon, digital inclusion is a key pillar of Citizen Verizon, Verizon's responsible business plan for economic, environmental and social advancement. As part of that plan, Verizon has a goal of reaching 10 million students with digital skills training by 2030.

Verizon Innovative Learning professional development has been proven as an effective way to promote technology integration within the 511 under-resourced schools in the U.S. that it currently serves. Based on a 2020 survey from an independent evaluator, Westat, Verizon has seen a significant impact on teaching practice:

- 92 percent of teachers said VILS helped them explore new ways of teaching
- 88 percent of teachers said VILS allowed for more individualised instruction
- 87 percent of teachers said that VILS enhanced their ability to differentiate instruction
- 93 percent of teachers said VILS made aspects of remote instruction easier
- 92 percent of teachers agreed that VILS professional development helped prepare them for remote instruction

As of June 2021, over 17,000 educators in the United States have accessed the Teacher Training Pathways in over 50,000 sessions. Creating virtual first offerings is necessary to scale Verizon's digital inclusion efforts to a broader audience in the United States. Now that Verizon has successfully digitized their professional development through the Teacher Training Pathways, it is continuing to offer more open access resources to support educators in the United States with technology integration.

Country: **Uruguay**
Title: **Ceibal at Home**
Implementer: **Ministry of Education**
Short description: As part of the Ceibal Plan and Ceibal at Home programme, the Ministry of Education designed an immersive and 360˚ training experience for teachers using the same resources and story-telling techniques as those intended to be adopted in their lesson plans. Teacher training was provided through low tech platforms suitable for adaptation to low connectivity contexts, such as analogue television, digital channels, including the Ceibal Plan LMS and social media. For example, there were podcasts delivered on Spotify also suitable for radio broadcast. Ceibal also experimented with a TV magazine with teacher training content, including strategies for remote and blended learning. Some of the suggested materials included over 1,500 Open Educational Resources and promoted the use of tools available among students, including instant messaging and social networks. A national survey suggested that Ceibal's educational resources were the ones most used by teachers in Uruguay and, according to Alexa ranking, its LMS was the fifth most-visited website in the country by mid-2020.

Country: **Portugal**
Title: **Escola Digital (Digital School) initiative**
Implementer: **Ministry of Education**
Short description: A strong example of leadership is seen in the Escola Digital (Digital School) initiative in Portugal. In the framework of the Digital School programme, the figure of the *Digital Ambassador* was created with the objective of streamlining the implementation of local digital transition plans. The Digital Ambassadors develop articulated work between the Directorate General of Education, the School Association Training Centres (CFAE) and the schools associated with those training centres. In this framework, the role of school leadership is very important in disrupting old practices and defining the strategies of each school.

I.2.3 School level readiness

Country: **Federal Republic of Brazil**
Title: **Guia Edutec: A Multidimensional Assessment of the Level of Adoption of Technology in Schools**
Implementer: **Ministry of Education and State Departments of Education**
Short description: *Guia Edutec* is a multidimensional assessment and online tool that sets out to assess and monitor school level readiness in the adoption of digital technology according to four key dimensions: vision, digital competencies, digital educational resources and infrastructure. The *Guia Edutec* platform collects data from public schools on these dimensions. They are then classified according to their level of readiness in each of the dimensions.

Guia Edutec is based on the Connected School (CS) conceptual framework developed by the Centre of Innovation for Brazilian Education-CIEB. A Connected School is perceived as a school with a clear vision for the pedagogical use of technology to support curriculum and pedagogical practices, principal and teachers with digital skills, quality digital educational resources and adequate infrastructure (devices and connectivity) for the use of technology for learning. The CS framework describes scenarios of a Connected School ranging from emergent (very low level of technological adoption), to basic, intermediary and advanced. According to the rubrics of *Guia Edutec* a school is ready to offer hybrid learning only when it reaches the intermediary level of adoption of technology, i.e. when it has integrated infrastructure and digital educational resources into its pedagogical planning and teachers are trained with digital skills to promote digital learning in a meaningful and effective way in both face-to-face and remote instruction.

Guia Edutec has been applied by all State departments of education in Brazil and contains data on a random sample of state public school (almost 30 thousand to date). The data shows that the least developed dimension of technology in Brazilian public schools is infrastructure, both in terms of lack of broadband connectivity in classrooms and in the number of devices available for students. Schools systems that have applied *Guia Edutec* over several years are able to monitor advances in each dimension and are using the results for strategic planning on investments in educational technology. Based on the overall results, the Ministry of Education and State Departments of Education in Brazil have also been able to earmark financing and design ICT policies to address the most urgent needs of each school in the provision of digital learning. Besides the Portuguese version *Guia Edutec* is being currently translated to Spanish, English and French and will be used by several other countries through a partnership with Fundación ProFuturo and the InterAmerican Development Bank-IADB.

I.2.4 Individual readiness

Country: **Mexico**
Title: **RECREA JALISCO platform**
Implementer: **Ministry of Education and State Government of Jalisco in partnership with Thincrs and Udemy**
Short description: Based on the foundations of the DigComp framework, the goal of this platform is to improve the digital skills of high school and undergraduate students and teachers in the State of Jalisco, in Mexico. To do this, the project works on 4 levels: (i) Diagnose public school teachers and students in digital competences using DigComp framework; (ii) Design and personalise learning paths for training teachers and students; iii) Certify teachers and students that reach the required levels of the DigComp framework; iv) Create digital education ecosystems. Launched in late 2019 and still running on 2021, it is a collaboration between the Government of Jalisco State, Thincrs and Udemy. An initial evaluation is performed through adaptation of the EU's DigComp framework that enables the design of personalised learning paths for each beneficiary. The incorporation of personalised learning paths with diverse evaluation moments further allows the engagement of users on the development of their digital abilities, since they can monitor their progress according to their interaction with the platform. So far, the initiative has supported the skills development of 4,100 teachers and thousands of students located in 12 geographic zones in Jalisco, Mexico. Some 2,346 teachers have levelled up their competencies from basic or mid-level to advanced level. Current results show that 24.84% of the users have accomplished outstanding levels on several competencies of DigComp Framework and 17.46% were able to develop the specialized level on DigComp Framework competencies.

II. Frameworks, indices and tools

II.1 Indices/rubrics for assessing systems readiness

II.1.1 International / institutional frameworks

Roadmap for Digital Cooperation: The Roadmap was presented by UN Secretary-General Antonio Guterres during a high-level virtual event on June 13, 2021. It follows the work from the High-level Panel on Digital Cooperation established in 2018 and has eight areas of focus: connectivity, digital public goods, digital inclusion, digital capacity building, digital human rights, digital trust and security, critical infrastructure, and global digital co-operation. To support this work moving forward, the UNSG plans to appoint a Technology Envoy, in order to advise the UN on emerging trends and threats. The Envoy will serve as a platform for multi-stakeholder communication.

The UN E-Government Survey: The UN E-Government Survey, published by the UN Department of Economic and Social Affairs (UN DESA), is prepared over a two-year period following an established methodology. It looks at how digital government can facilitate integrated policies and services across 193 UN Member States. In the report of the Secretary-General's High-level Panel on Digital Cooperation, the E-Government Survey is recognized as a key ranking, mapping and measuring tool, supporting the digital transformation of countries. Following the global launch of the 2020 Survey on 10 July, technical webinars are scheduled to share further insights and key findings at the global, regional and local levels, including on thematic areas such as e-participation, data governance and capacities for digital transformation. In addition to the English edition, the Survey will also be made available in Arabic, Chinese, Russian and Spanish, thanks to the collaboration with external partners.

Global Information Technology Report: This report was produced as a collaboration between INSEAD, the World Economic Forum and the World Bank. It ranked the world economies in terms of networked readiness and effects on economic growth and productivity.[7] It also featured the latest iteration of the Networked Readiness Index, which assesses the factors, policies, and institutions that enable a country to fully leverage information and communication technologies for increased competitiveness and well-being.

Measuring the Information Society report: This is an annual report published by the International Telecommunications Union since 2009. It features key ICT data and benchmarking tools to measure the information society, presenting a quantitative analysis of the information society and highlighting new and emerging trends and measurement issues. The analytical report is complemented by a series of statistical tables providing country-level data for the indicators included in the ITU ICT Price Basket.

7 Please note that the 2016 Global Information Technology Report is the last edition of the series. No updates are available.

II.1.2 Non-government and corporate examples

Automation Readiness Index: Developed by ABB and the Economist, the Automation Readiness Index surveyed and ranked 25 countries on their automation readiness, meaning their ability to integrate Artificial Intelligence and robotics-based automation into their economies, businesses and workforces. The analysis in the report is based on a new and original index, built by The Economist Intelligence Unit, as well as a series of in-depth interviews with subject matter experts from around the world. Rankings were determined based on a total of 52 qualitative and quantitative indicators selected in consultation with experts in automation, education and economics.

Digital Planet Digital Evolution Index (DEI): Digital Planet is an interdisciplinary research initiative of The Fletcher School's Institute for Business in the Global Context dedicated to understanding the impact of digital innovations on the world and providing actionable insights for policymakers, businesses, investors, and innovators. The Digital Evolution Index is a data-driven study of the pace of digital growth across four key drivers that govern a country's evolution into a digital economy: demand conditions, supply conditions, institutional environment and innovation, and change. To gain a comprehensive view of digital readiness across countries, the index further divides these drivers into 12 components, measured using a total of 99 indicators to create an overall digital evolution score and digital momentum score. The current index encompasses the third edition of the Digital Evolution scorecard, following up on the earlier editions (in 2017 and 2014) and the second edition of the Digital Trust scorecard. This edition offers data, insights, and international comparisons to guide decision-makers to chart a path out of the pandemic-induced economic challenges of 2020 and toward a data-enabled, artificial intelligence-augmented, and inclusive digital future.

KPMG Change Readiness Index: This index measures a country's overall change readiness for any type of transformation. It splits the measurement into three dimensions-enterprise; government; people and civil society capability to change - emphasising the critical role of human capacity/skills and processes to support and sustain systemic changes, regardless of their nature.

Government Artificial Intelligence (AI) Readiness Index: Oxford Insights and the International Research Development Centre publish the AI Readiness Index which measures governments' readiness to implement AI in the delivery of public services to their citizens. It also looks at the capabilities and enabling factors required for a government to be ready for AI implementation, but it does not measure the implementation itself.

The Inclusive Internet Index: Commissioned by Facebook and developed by The Economist Intelligence Unit, the Index seeks to measure the extent to which the Internet is not only accessible and affordable, but also relevant to all, allowing usage that enables positive social and economic outcomes at the individual and group level. Now in its fifth year, the index assesses the performance of 120 countries in four categories of inclusion: Accessibility, Affordability, Relevance and Readiness. Each category incorporates key indicators of Internet inclusion, including quantitative measures such as network coverage and pricing, and qualitative measures such as the presence of e-inclusion policies and the availability of local-language content. To assess availability, for example, the Index measures existing internet use, connection quality, and the type of infrastructure available for Internet and electricity in both urban and rural areas. Local governments and advocacy organizations can use this information to plan their work in expanding connectivity or to advocate for additional investments.

II.2 Digital skills frameworks

II.2.1 International / institutional frameworks

Broadband Commission's Digital Skills Framework: In 2017, the Broadband Commission Working Group on Education published a report titled "Digital skills for life and work", with the ambition to examine the implications of the 'broadband society' for the development of digital skills at country level and by local communities. In this report, skills required for the digital society and digital economy are described in terms of two broad and distinct areas: (i) Basic functional digital skills: Necessary and foundational skills for accessing and engaging with digital technologies; (ii) Generic digital skills: A broad range of intermediate skills and competencies are required to make use of digital technologies in meaningful and beneficial ways.

Digital Competence Framework for Citizens (DigComp): Since 2013, the European Commission has provided the DigComp, a common language to describe digital competence. DigComp was developed by the European Commission's Joint Research Centre (JRC) and has become a reference for the development and strategic planning of digital competence initiatives both at European and Member State level. DigComp describes what digital competence is and groups the competences in five areas: Information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. Its latest version, DigComp 2.1 (published in May 2017), describes those competences across eight proficiency levels, from foundation/beginner to highly specialized, and offers examples of use applied to employment and education in the form of infographics and visual guides.

Digital Literacy Global Framework (DLGF): The Digital Literacy Global Framework, developed by UNESCO in 2018, provides a reference on digital literacy skills for Sustainable Development Goal indicator 4.4.2: "Percentage of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills". DLGF was built on DigComp 2.0 as the initial framework, based on empirical studies, including an evaluation of existing regional, national and sub-national frameworks to identify competences relevant for the global context, as well as an assessment of digital literacy competences required in use cases of digital technology in some major economic sectors. UNESCO included two new competence areas and competences to the DigComp 2.0 framework: 0. Devices and Software Operations and 6. Career-related competences.

Digital Intelligence (DQ) competency framework (2019): Digital Intelligence (DQ) is a comprehensive set of technical, cognitive, meta-cognitive, and socio-emotional competencies that are grounded in universal moral values and that enable individuals to face the challenges and harness the opportunities of digital life. DQ has three levels, eight areas, and 24 competencies composed of knowledge, skills, attitudes, and values. The world's first global standard related to digital literacy, digital skills, and digital readiness, the IEEE 3527.1™ Standard for Digital Intelligence (DQ), was approved by the IEEE Standards Board on 24 September 2020.

Digital Skills Open Knowledge Repository (World Bank Group): This repository offers information on frameworks and programmes promoting highly specialized digital skills which could in theory be available to citizens and the general workforce. For the ICT professions, these skills, representing e-4 and e-5 levels of the EU e-Competence framework, are typically provided at the postgraduate level (Masters and doctorate level) focusing on advanced computer science/ engineering, applied mathematics and related fields, and cater to occupations such as data scientists and AI engineers.

ITU Digital skills toolkit: The ITU Digital Skills Toolkit was developed in 2018 to provide policymakers and other stakeholders with practical information, examples, and step-by-step guides to help plan national digital skills strategy (ITU, 2018). The toolkit references the three-level categorization of the 2017 Broadband Commission report, presented in the previous section. The toolkit further highlights the relevance of skill categories that are either core to existing curricula or on the rise including: (i) Online safety skills; (ii) 21st Century skills - organized under three 'pillars': Foundational skills-Competencies-Character qualities; (iii) Emerging and specialized skills. These are the skills on the rise and include - Computational thinking and coding-Data literacy-Mobile literacy.

The Smart Africa Digital Academy (SADA): This is a pan-African framework and dynamic learning ecosystem which federates national and regional efforts to tackle the lack of digital skills in Africa. Through the fostering of multi-stakeholder alliances, the expectation is that African citizens of all ages and social classes can gain or improve their digital skills, gain qualifications, meet the emerging talent needs of employers, industry or be self-reliant. Specific goals include: (i) Enabling policy formulation and national digital skills development frameworks; (ii) Promotion of ICT literacy for all, enabling citizens to access and engage with digital technologies;
(iii) Enabling ethical citizenship in the digital age through behaviours that take into account the social and cultural diversity of the digital society; (iv) Reforming and strengthening the integration of 21st Century Skills in education through curriculum adaptation and provisioning of short courses; (v) Empowering policy makers with the required skills and knowledge to develop harmonized policies for a successful digital transformation; (vi) Develop best practice principles framework for using technology in Teaching and Learning; (vii) Mobilizing strategies and tools to address the needs of the marginalized and vulnerable citizens. SADA currently partners with the atingi.org learning platform to focus on competency-based learning which will offer 4 keys services: Capacity building for decision-makers; Programmes for digital inclusion; Skills marketplace for professionals; and a talent bridge for businesses. In 2020, the SADA platform also trained over 200 policy and decision-makers from 21 African countries.

II.2.2 Non-government and corporate examples

Ericsson common skills-based language and taxonomy: Ericsson has strategically invested in workforce development and growth over the next decade through up-skilling and re-skilling. To do this, the company has redefined its learning and development strategy, set-up and delivery model, and created a common skills-based language and taxonomy, making it clear what each skill means. This framework enables the benchmarking of workers and people against critical skills. A combination of assessments are possible; some are self-assessments; some involve an assessment where people demonstrate their contributions, while some involve project-based knowledge. Once people know their skill level on a particular area of expertise, getting to the next level requires gaining new credentials, including through micro degrees through university partnerships, real-world projects to work on, or experiential, hands-on labs based learned for deliberate practice. Data analytics measure progress and make it visible and accountable through skill dashboards. They also make it easy for people to see and share their skill progression profiles, to discover and connect to critical skill assignments and new job opportunities.

World Economic Forum's Global Skills Taxonomy: The FEW Global Skills Taxonomy, published in January 2021, is intended to provide a common language for employers (and learning content providers) to map their own taxonomies against the global framework and is being established as a major common reference for corporate learning. The framework is design to cluster skills depending on their similarities and provide 5 levels of increasing granularity. "Levels 1-3 remaining constant as the foundational framework; level 4 provides opportunities for adding skills as the skills landscape continues to transform; and level 5 is determined by the end user of the taxonomy (i.e. employers, learning providers and governments). This report also explores context-based learning paths for digital skills to support the development, implementation and assessment of digital skills strategies and programmes by different stakeholders, from policy makers, content developers, corporate learning organizations, civil society and academia. Three major paths are proposed: (i) Digital Literacy for citizenship; (ii) Digital skills for hybrid learning, and; (iii) Digital skills for work. For each of these paths a mapping is done to a range of skills and competencies that enable the assessment and evaluation of each individual's readiness for the specific activity (digital citizenship, hybrid learning and digital work).

II.3 Digital transformation within education systems

II.3.1 Assessments of education system readiness

UNESCO Global Media and Information Literacy Assessment Framework: The MIL Assessment Framework offers UNESCO Member States methodological guidance and practical tools throughout the assessment of country readiness and competencies, particularly of teachers in service and in training, regarding media and information literacy at the national level. The Framework provides methodological guidance for the national adaptation process, with six phases and various practical tools. On the basis of the assessment results, countries will be enabled to make informed decisions for interventions aimed at the further development of MIL, by fostering an enabling environment and enhancing the competencies of their citizens. These are free to download and available in English only.

World Bank SABER education diagnostic tools: The Systems Approach for Better Education Results (SABER) was launched by the World Bank in 2011 to help identify the education policies and programmes most likely to create quality learning environments and improve student performance, especially among the disadvantaged. SABER produces comparative data and knowledge on education policies and institutions, with the aim of helping countries systematically strengthen their education systems and the ultimate goal of promoting Learning for All. It allows countries to conduct a thorough inventory of their education policies and institutions based on global best practices, as well as providing decision makers and stakeholders at all levels with tools for structured and effective policy dialogue. These are free to download and available in English only.

HEInnovate framework: HEInnovate, developed by the European Commission and the OECD, is a self-assessment tool for Higher Education Institutions who wish to explore their innovative potential. It guides them through a process of identification, prioritization and action planning in eight key areas. It also diagnoses areas of strengths and weaknesses, opens up discussion and debate on the entrepreneurial/innovative nature of the HE institution and allows it to compare and contrast evolution over time. Users can have instant access to results, case studies, learning materials and a pool of experts to help them design solutions tailored to their needs. The tool can be used by all types of higher education institutions. It is free and confidential. Free to download. Available in 24 languages for higher education institutions to organize strategic discussions and debate around entrepreneurship and innovation, and HEInnovate country reviews

II.3.2 Skills frameworks for assessing teacher readiness

DIGCompEdu: The European Framework for the Digital Competence of Educators (DigCompEdu) is a scientifically sound framework describing what it means for educators to be digitally competent. It provides a general reference frame to support the development of educator-specific digital competences in Europe. DigCompEdu is directed towards educators at all levels of education, from early childhood to higher and adult education, including general and vocational education and training, special needs education, and non-formal learning contexts. Free to download. Available in English only with national translations.

SELFIE self-reflection tool: SELFIE for Teachers is an online tool, developed by the European Commission DIGCompEdu to help primary and secondary teachers reflect on how they are using digital technologies in their professional practice. Teachers can use the tool to learn more about the digital skills they have and identify areas where they can develop further. SELFIE for Teachers' questions and statements relate to uses of technology in the following areas: professional communication and collaboration; personal learning and development; finding and creating digital resources; teaching and learning practice;

student assessment and; facilitating student digital competences. On completing the statements, the teacher automatically receives a report on their proficiency level in each of the areas with suggested next steps. Based on their results, teachers can design their learning pathways to further develop their digital competence and confidence. Answers provided are always anonymous. Free to consult online. Available in English only with national translations.

UNESCO ICT Competency Framework for Teachers (ICT CFT): The ICT Competency Framework for Teachers is a result of a partnership between UNESCO, CISCO, INTEL, International Society for Technology in Education (ISTE) and Microsoft. Its intention is to guide educational policy makers and professional learning development providers in the development of pre- and in- service teacher training on the use of ICTs across education systems. The motivation is that "teachers who have competencies to use ICT in their professional practice will deliver quality education and ultimately be able to effectively guide the development of students' ICT competencies" (UNESCO, 2018b). The ICT CFT provides a comprehensive set of competencies teachers need to integrate ICT into their professional practice in order to facilitate students' achievement of curricular objectives. The framework consists of 18 competencies organized according to the six aspects of teachers' professional practice, over three levels of teachers' pedagogical use of ICT. Further details on the framework can be found in the Appendix. Version 3 of the CFT was published in 2018. The updated version incorporates inclusive principles of non-discrimination, open and equitable information accessibility and gender equality in the delivery of education supported by technology. The impact of frontier technologies such as Artificial Intelligence (AI), Mobile Technologies, the Internet of Things and Open Educational Resources is also investigated. Free to read online. Available in several languages: English, French, Arabic, Chinese, Russian, Spanish, Khmer, Kyrgyz and Tajik.

II.3.3 Programmes and frameworks supporting school level readiness

The Giga Initiative: Launched in 2019 by UNICEF and the International Telecommunications Union in collaboration with Ericsson, Dubai Cares and the Musk Foundation, the aim of the Giga Initiative is to provide connectivity to every school in the world. Operationally, the project is working with governments to map connectivity demand, using schools as a base point, and identifying where there are connectivity gaps. This information, combined with existing ITU mapping data, will allow countries to take stock of their existing infrastructure and assess appropriate solutions for connecting schools. In partnership with industry, and based on the mapping results, Giga will subsequently advise on the best possible technical solutions to provide schools with connectivity, and countries with safe, secure, reliable, fit-for-purpose infrastructure to support future digital development needs. This includes determining the best possible solutions for last mile connectivity. Over 900,000 schools in 35 countries have so far been mapped and are viewable live at www.projectconnect.world.

II.3.4 Examples of toolkits and metrics supporting individual's digital readiness

EILab Digital Competency Profiler: The Profiler is a free tool that provides individuals with a snapshot of how they use digital technology in their lives, generating a personal visual profile of their relative competency and use of technology in four basic orders: technical, social, informational and computational. This profile can then be used by individuals and/or organizations in planning for further development of the digital competencies that are foundational elements in successful careers in academia, commerce, service, or entrepreneurship. It is based on a model developed by Dr. François Desjardins.

General Technology Competency and Use (GTCU) framework: Also authored by Dr. François Desjardins, the GTCU framework conceptualizes digital-technology abilities across three primary dimensions: Epistemological (E), Informational (I) and Social (S). These dimensions are explicitly aligned with the IEEE definition of computer hardware: "physical equipment used to process (E), store (I), or transmit (S) computer programmes or data." The GTCU offers researchers and educators a streamlined model with demonstrated effectiveness for surveying the digital readiness of individuals and groups for technology-enhanced working and learning. The GTCU overlaps conceptually and operationally with other academic, digital-abilities frameworks like that of Van Deursen and Van Dijk (The Netherlands), Eshet (Israel) and Ferrari (EU). Two unique characteristics of the GTCU are: (i) its Epistemological dimension, which relates to computational competencies of high importance to professional "power users" in creative, scientific, technological and information-intensive domains, and (ii) its proprietary data-collection instrument, an online application that provides users with a rich and visually engaging digital-competency profile.

GSMA Mobile Internet Skills Training Toolkit (MISTT): The GSMA represents the interests of mobile operators worldwide, uniting more than 750 operators with almost 400 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The Mobile Internet Skills Training Toolkit (MISTT), developed by GMSA, is a set of free resources to teach people basic skills to access and use the mobile internet. The toolkit also offers Mobile Network Operators (MNOs), Non-Governmental Organizations (NGOs), Development Organizations and Governments the tools to drive awareness and use of the mobile internet.

Trainees are equipped with a deeper understanding of what they can use the internet for, and the basic skills needed to access and use it. To achieve this goal, the toolkit uses a 'train the trainer' approach, with short lessons provided in a PDF format that can be easily adapted to local needs and languages. A combination of different distribution models for MISTT content has also proven to be very effective, especially during the COVID pandemic. This includes (in addition to the face-to-face training) sending links to MISTT content via SMS, hosting voice-only mini tutorials through IVR and creating video or content accessible through an app.

So far, around 23 countries across Sub-Saharan Africa, Latin America and Southeast Asia have launched the toolkit since its inception. Eight groups of MNOs are engaged in pilots as well as five tech companies and digital players. Some 21 million users trained worldwide. Looking ahead, diversifying the format of the content, using a combination of video and print materials would further enable providers to meet the needs of people with low literacy levels and reach more people.

Technology Readiness Index TRI 2.0: In 2000, Parasuraman published the first Technology Readiness Index (TRI) scale which consists of 36 items and has been widely used in academic and commercial contexts. In 2015, Parasuraman and Colby published a more streamlined scale consisting of 16 items called TRI 2.0 (also referred to as TechQual™). This includes measures of overall technology readiness (TR) as well as individual components of technology readiness (optimism, innovation, discomfort and insecurity). Based on TRI 2.0 scores on the index's four individual components, Parasuraman and Colby also derived a segmentation scheme that categorizes people into five technology adoption segments (Explorers, Pioneers, Skeptics, Hesitators, and Avoiders).

Thincrs: Thincrs is a skill development platform for students and job seekers. The platform evaluates candidate skills using assessments and suggests careers related to their skills and provides courses to develop their skills and experience. It also connects candidates to employers to get hired. Employers can view candidate skills and hire candidates. The platform was founded in 2016 in San Francisco.

II.3.5 Examples of Ed-Tech tools (platforms, contents and resources)

- International

Kolibri: Developed by Learning Equality, Kolibri is an adaptable end-to-end suite of open tools, openly licensed learning resources, and do-it-yourself support materials, designed for teaching and learning with technology in environments where there is little or no Internet connectivity, particularly during the COVID-19 pandemic. At the centre of this ecosystem is an open-source learning platform that provides robust functionality to support the kinds of personalized and differentiated learning that are typically only available in online learning environments. The wealth of open resources from its library, along with locally developed materials, can be aligned to a national curriculum using the Kolibri Studio curricular tool, and educators within the learning platform can create lessons and quizzes with these resources. From there, Kolibri enables educators to facilitate remote learning by capturing learning analytics, allowing teachers to track learner progress, and get notifications for when additional support for individual learners is needed — all without needing access to the Internet.

Kolibri is specifically focused on equity, as it is designed with contextual considerations for the particular learning environments where the most marginalized learn. It leverages hardware that already exists, from networking infrastructure to existing computer labs, and also runs on a variety of low-cost devices. It can support learning without large-scale infrastructural investment, and is responsive to needs, including limited teacher capacity and training, limited digital literacy, large class sizes, and differing learning abilities within a single class. It is an adaptable and flexible solution specific to low-connectivity contexts, which is how, for example, it can be used for literacy learning for diversely-abled learners in Uganda and also to support STEM skill development by refugee learners in Jordan. It can be leveraged in contexts with limited access to electricity, and where the Internet is costly and/or not prevalent. Lastly, Kolibri is low-maintenance: while it is not low-tech, it is a robust learning platform extensively tested in low-connectivity learning environments.

In a more developed version of Kolibri scheduled to be launched in late 2021, Learning Equality is releasing new functionality to enable educators to monitor and offer support to students -- both through Kolibri and through side channels, such as SMS or WhatsApp. This will allow learners with no Internet access to learn at home, while still benefiting from teacher support through remote facilitation.

Udemy: Udemy is a leading online learning platform and marketplace connecting course creators and learners. Anyone can take a course on the platform, and anyone can publish and sell a course. According to Udemy's official statistics over 30,000,000 people have taken a course on Udemy, and the overall number of enrolments has surpassed 190,000,000. The platform features 100,000 courses from 42,000 instructors around the world.

Sub-Saharan Africa[8]

OkpaBac: Founded in January 2016 by the Togolese start-up OkpaFaces, OkpaBac is a platform delivering educational resources to high school students to prepare for the Baccalaureate. The mobile app contains summaries of lessons, sample examinations from previous years and quizzes to test knowledge. At the moment the app is only available for Android devices but the founding team plans to scale and make it compatible with other operating systems.

Samaskull: Samaskull is a new kind of Coursera but 'Made in Senegal.' The e-learning platform enables users to access a database of unlimited educational materials. 'Made by Africans, for Africans'. Samaskull provides interactive Massive Open Online Courses (MOOCs) and Small Private Online Courses (SPOCs) for those who prefer one-on-one private lessons.

Eneza: 'To reach' in Swahili, Eneza is an educational platform that acts as a virtual tutor and teacher's assistant for thousands of Kenya-based students. Eneza's model is to partner with schools in Kenya to track and assess students' knowledge using the country's most common form of technology: the mobile phone. Students access educational quizzes, a live 'Ask-a-Teacher' feature, offline access to Wikipedia, a dictionary and other learning materials via SMS. The platform is specifically geared towards Kenyan primary students in the upper primary grades as they prepare for the test (KCPE) crucial for their entry to secondary school. Using the high-quality content platform, students are able to hone and test their knowledge.

Obami is a free to use social learning platform from South Africa that helps connect everyone in the learning space. Students can make a profile and connect with people from around the world, get news from schools, and submit school work. It works very much like a social media with a heavier focus on education. In 2014, the start-up launched a mobile app, Obami Tutor that focuses on private tutoring to help South Africa-based students. The platform connects learners on their mobile phones to real-life qualified tutors. Obami Tutor revolutionizes the traditional model of private tutoring, by bringing quality and affordable tuition to any learner anywhere in South Africa.

8 Source: 10 E-Learning Platforms Transforming Education in Africa. Accessed 23.08.21.

Ubongo [Ubongo is a Swahili word meaning 'brain'.]: This is a Tanzanian social enterprise creating interactive edutainment for young learners in Africa, delivered via existing technologies. The main product, *Ubongo* Kids, is an educational cartoon broadcast daily on Tanzanian national TV that incites primary school kids to '*tumia ubongo*' ('use your brain' in Swahili) by teaching them math and sciences through animated stories and original songs. The children can use basic mobile phones to answer multiple-choice questions via SMS and they receive feedback from their favourite cartoon characters. Nine months following the official launch in 2014, *Ubongo* Kids reached 6 per cent of all households in Tanzania, with viewership in one out of four homes with a working TV.

Sterio.me is a Nigerian start-up that provides a service using SMS to give students access to material and lessons they listen to outside the classroom. In a nutshell, teachers pre-record lectures, quizzes and questions and send them for free by using a specific SMS code. Educators are notified when students have finished the lessons and receive their students' respective performance. It saves them grading time, and they can provide immediate feedback to the students who ask for it. Sterio.me does not require internet access and can be accessed through any basic phone. In 2014, Sterio.me announced a strategic partnership with Tutor.ng in launching a full-stack mobile learning experience across Nigeria. It includes the SMS and voice-based mobile education services of Sterio.me and e-learning via the mobile web, Tutor.ng platform.

- South America

Akdemia: Founded in 2012, Akdemia is revolutionising education management by helping schools in Latin America to simplify their operations. The all-in-one platform provides schools and their communities with a way to stay informed and up-to-date with everything happening both inside and outside the classroom.

Colegium: The goal of Colegium is to improve the overall management of schools with technology. The platform has 50+ useful applications for schools and parents, including communication tools, billing and collections, extracurricular activities, library administration, and more. The company was founded in 2000 in Chile and now has a presence in Chile, Argentina, Mexico, Colombia, Peru, Brazil, and Uruguay.

Edoome: Edoome makes it easy for teachers to set up virtual classrooms where they can share files and videos with their students, publish grades, and share assignments or quizzes. Recently, the company closed a deal with the Ministry of Education of Chile to implement the platform in all public schools in Chile, impacting more than

Veduca: Based in Brazil, Veduca is an online video platform that aggregates and curates educational content from top universities around the world. Its library includes thousands of videos from institutions in Brazil and abroad.

Já Entendi: Also from Brazil, is designed to prepare high school and pre-university students for the standardized tests required to enter higher institutions of education. Its content has been created to be accessible and enjoyable for students who otherwise may not take the university path.

Ludibuk: Ludibuk is a Chile-based startup that provides a digital library of books for K-12 Spanish-speaking students. Teachers can provide customized feedback and view real-time reports on a student's progress.

Poliglota: Also based in Chile, Poliglota is dedicated exclusively to language. The world's first language education social network, the start-up brings together over 35,000 language learners around the world in face-to-face meetups.

- Asia

Yuanfudao: Founded in 2012, Yuanfudao is one of China's leading online education companies. It offers diversified technology-empowered education services, providing a variety of products including the online tutoring app Yuanfudao, the smart learning app Zebra, the self-adaptive question bank Yuantiku, intelligent correction tool Xiaoyuan Kousuan, and Xiaoyuan Souti, an app for searching and answering question.

BYJU: This is a Bangalore-based educational technology and online tutoring firm founded in 2011. Byju runs on a freemium model, with free access to content limited for 15 days after the registration. It was launched in August 2015, offering educational content for students from classes 4 to 12 and in 2019. It also trains students for examinations in India such as IIT-JEE, NEET, CAT, IAS, and international examinations such as GRE and GMAT. Academic subjects and concepts are explained with 12-20 minute digital animation videos. In 2019, the company announced that it would launch its app in regional Indian languages. It also planned to launch an international version of the app for English-speaking students in other countries. Recently, Byju's launched new programmes in its Early Learn App for students of kindergarten. In April 2021, the company further announced the launch of "BYJU'S Future School" to be led by WhiteHat Jr Founder Karan Bajaj. The Future School aims to cross the bridge from passive to active learning with an interactive learning platform blended with coding and other subjects like Math, Science, English, Music and Fine arts through storytelling. BYJU'S will launch the Future School in the USA, UK, Australia, Brazil, Indonesia and Mexico in May.

III. Frontier education technologies

III.1 Examples of corporate efforts to support 5G and Wi-Fi 6

Since 2000, **TELUS**, the Canadian 5G and telecom provider, has invested almost $240 billion in network infrastructure, spectrum and operations across the country to enhance the coverage, speed and reliability of its world-class network and connect customers from coast to coast to coast. Since the pandemic began, it has deepened efforts to expand its network into more rural and remote regions, noting that its 5G technology is now available in 81 cities and towns across the country and continuously expanding. This is helping in connecting people regardless of their socio-economic status. Internet for Good offers eligible low-income families in B.C., Alberta and Quebec access to low-cost, high-speed internet. The company has so far donated over 15,000 data plans to facilitate Quebec's low income students' return to the classroom. On-going initiatives to support digital access and safe digital education also include TELUS Wise - a free educational programme designed to help keep Canadian students (Grade 6-12) and youth safe in the digital world. The programme offers interactive and informative workshops and resources to help learners and youth have a positive experience as digital citizens. Topics include cyberbullying, protecting online reputations, identity theft and more.

In the United States, **Ericsson** has worked with Vermont Telephone (Vtel) to bring mobile internet to high school students in Rutland, a city where many families do not have sufficient broadband connectivity for remote learning. Ericsson expedited the delivery and installation of next generation 4G/5G wireless radios and antennas on a building in downtown Rutland. VTel delivered wireless modems and routers to homes, allowing students to receive free Internet service immediately. It all happened in less than 10 days, helping local students get the most out of remote learning.

In July 2020, **Huawei** launched the DigiSchool project in partnership with local operator Rain and the educational non-profit organization Click Foundation. The project is in response to the South African government's call to ensure that all children can read fluently – and understand what they are reading – by the end of grade three. Huawei is providing the Click Foundation with connectivity equipment and the funding to provide high-quality learning resources for the schools, while Rain will get them online with its 4G and 5G networks. The partners are aiming to achieve this by connecting more than 100 urban and rural primary schools to the Internet over the next year.

In India, **C-DOT** and **Intel** ran a trial focusing on the capability of Wi-Fi 6 in comparison to Wi-Fi 5 to heighten and evaluate the performance of streaming educational video contents to students using mixed client devices in rural schools. In India, Wi-Fi 6 is a new and very important frontier technology for the digital learning. It brings many new features such as faster, more responsive and reliable connectivity and supports different uses which were not considered possible with earlier versions of Wi-Fi technology. Trial participants included C-DOT, Intel, school/NGO/State agencies. The trial has enabled C-DOT to evaluate and improve the design requirements for the Wi-Fi 6 Network for Smart village applications in real time in mixed client scenarios. It provides new possibilities for immersive experiences and wireless transformation in digital learning.

WeSchool 5G Smart School is a joint initiative between Qualcomm® Wireless Reach™, WeSchool and Telecom Italia (TIM) Operazione Risorgimento Digitale. The aim of WeSchool, accredited by the Italian Ministry of Education and the main digital learning player in Italy with 1.7million students and 230 thousand teachers subscribed, is to help students and teachers to innovate education every day, by providing both teacher training and an online teaching and learning management platform enabling users to fully realize the benefits of digital education tools. 5G Smart School will deliver guided activities, tutorials, and bite-sized learning modules through cooperative learning, gamification, and role play. TIM *Operazione Risorgimento Digitale*, the educational program was launched in 2019 by TIM with the aim of accelerating digital inclusion in Italy. It provides TIM's 5G network the opportunity to transform today's digital teaching and learning environment by enabling ultra-reliable connections, seamless interactivity and expanding opportunities for collaborative educational experiences. Participating teachers in the 5G SMART School will utilize Qualcomm® Snapdragon™ 5G-enabled PCs on Windows, ensuring lighting-fast performance and enterprise-grade security. Secondary schools will benefit from the next generation's wireless technology solutions so that teachers and students can take advantage of digital tools in and out of the classroom, as well as content and experiences to enhance their learning experience. Holistic implementation will encompass hardware and connectivity, access to content and assessment via a dynamic learning platform, teacher training, continuous teacher assistance and an impact evaluation to ascertain the benefits for teachers and students. This program is expected to launch in September 2021.

III.2 Examples of educational technologies using AI

- Europe and North America

Knewton: This educational technology creates adaptive learning technology for higher education. Its programme, called alta, helps identify gaps in a student's knowledge, provides relevant coursework and places students back on track for college-level courses. Alta also helps instructors teach at different educational levels and is currently used for math, chemistry, statistics and economics.

Cognii: Cognii makes AI-based products for K-12 and higher education institutions, as well as corporate training organizations. Its virtual learning assistant employs conversational technology to guide students in open-format responses that improves critical- thinking skills. The assistant also provides real-time feedback, one-on-one tutoring and is customized to each student's needs.

Century Tech: The platform utilizes cognitive neuroscience and data analytics to create personalized learning plans and reduce workloads for instructors. The AI platform tracks student progress, identifies knowledge gaps and offers personal study recommendations and feedback. Century also gives teachers access to resources and reduces time spent planning, grading and managing homework.

StorySign: A revolutionary free mobile application to help the deaf children aged 3 to 6, uses mobile AI to translate popular children's books into sign language. The StorySign App uses the power of Huawei's mobile AI technology to read text at 45 degrees with seamless image recognition, and even works in low-light conditions for bedtime stories. The StorySign App scans the words in selected children's books and instantly translates them into sign language, using the most advanced signing avatar. For the first time, deaf children and their parents have the possibility to learn read and sign, together.

- Sub-Saharan Africa

Daptio: Founded in 2013, this Cape-Town based start-up has rapidly positioned itself as a leader in adaptive learning. Daptio uses artificial intelligence to help students, mentors and teachers to understand the proficiency level of each student. The goal is to find a model that allows students to receive the right content, leading to a more tailored education and higher grades.

III.3 Examples of programmes focusing on AI and digital skills preparation

Teaching AI for K-12 Portal: AI has been floated as a tool to help people cope with the pandemic, but only if people have a full understanding of what the technology is. UNESCO and Ericsson recently launched the Teaching AI for K-12 Portal to help build that fundamental curriculum for young people.

With the rapid deployment of advanced technologies such as mobile broadband, cloud, IoT, automation and AI, a new set of skills is required to enter the workforce. There is an unprecedented opportunity to harness technologies and use them to advance not only economies but also to combat some of the world's looming challenges.

With this background, Ericsson and UNESCO are combining their respective strengths to create opportunities to scale up skill development in AI and other key digital skills for young people. Under the AI for youth initiative the partners will:

- Develop and manage a repository of AI and other key digital skill training courses that will be available globally.
- Build capacities of master trainers from selected countries around the globe with advanced knowledge of AI skill development.
- Support master trainers to mobilize AI hub centres and hackathons to train young people on developing AI applications.

Open P-TECH: Open P-TECH is part of IBM's commitment to invest in human intelligence. This free digital education platform equips 14- to 20-year-old learners with foundational technology competencies. It emphasizes training in highly valued technologies and professional skills including AI, cloud computing, cybersecurity, and design thinking. It offers content in English, Portuguese and Spanish. The platform builds upon the P-TECH (Pathways to Technology Early College High School) model that IBM launched in 2011. Since then, 220 schools across 24 countries have adopted the model, with over 150,000 students and 600 corporate partners.

III.4 Examples of VR applications in basic education

Pioneering VR in education: VR contents are available in current educational applications; Universiv, Alchemy VR, Google Expeditions, Discovery VR, zSpace, Woofbert VR, and Nearpod are just a few of the initiatives.

AR app Froggipedia: This app allows students to study a frog's internal organs without harming any real frogs. It also enables students to visualize the transformation of frogs from tadpoles into their adult form.

VirtualSpeech, a VR tool. Helps individuals work on their public speaking skills in a more effective and realistic manner.

III.5 Examples in AI higher education

University of California, San Diego (USA) develops an intelligent tutoring system: UC San Diego computer science professor Pavel Pevzner and colleagues have developed the first online advanced undergraduate course designed specifically as an adaptive intelligent tutoring system (ITS). It was developed for the edX platform. *The Introduction to Genomic Data Science* course gives learners access to the best content in the field, and importantly, through the ITS, it provides an adaptive and personalized learning path for each online student enrolled in the MOOC. This is achieved through quizzes and "just in time" exercises that allow for continual evaluation of each student throughout the course.

Imagine Learning's Imagine Math 3-8 programme offers just-in-time live teacher access for students using the software-based educational programme. Using a wide array of metrics, the programme implements AI, or machine learning, to identify when a student needs support right in the moment of struggle. The programme interjects an invitation to the student on their screen within seconds, as if a live teacher were on the other end asking if the student needs help. When a student engages, live teachers join the conversation—via chat or live conversation—giving the individual students the instruction and support they need to move forward in their personal learning path.

III.6 Examples of block chain application

Insignias INTEF Open Badge Backpack: Digital competency badges are stored and available on any Internet connected device, with the peace of mind that their storage is in a safe environment accessible via an encrypted connection. The Backpack is automatically connected to various digital learning management systems. Additionally, digital badges can be imported across other open backpacks. They can also be shared on social networks (Twitter, Google+, Facebook) or shown on LinkedIn to complete professional profiles.

National Open Badge: The aim of this European Social Fund project, coordinated by the Oulu University of Applied Sciences, is to develop a nationwide open badge constellation, which enables the verification of adults' problem-solving skills in technology-rich environments by identifying and recognising competences acquired outside the formal education system at different levels of education and in transition phases of the education structure. The open badges created by the project will be piloted within different target groups in VET and adult education, including preparatory training for VET, integration training for migrants, adult students developing basic skills and in upper secondary VET.

Europass credentials: The processes of validation and certification are also becoming digitized, including through digital credentials, like open badges. As part of the new Europass, the European Commission is developing free tools and services to support the issuance of authentic, tamper-proof digital credentials by education and training institutions to confirm the awarding of a qualification to a person. Graduates and learners will be able to receive their qualifications in digital form to share with employers and education and training institutions who can instantly verify that the qualification, or other learning credential, is authentic and issued by a recognised awarding body. Currently, 18 countries are engaged in piloting Europass credentials. It is expected that the first results from the piloting will be announced by April 2020.

III.7 Examples of cloud based platforms

Google Classroom: is a free web service developed by Google for schools that aims to simplify creating, distributing, and grading assignments. The primary purpose of Google Classroom is to streamline the process of sharing files between teachers and students. As of 2021, approximately 150 million users use Google Classroom. Google Classroom integrates Docs, Sheets, Slides, Gmail, and Calendar into a cohesive platform to manage student and teacher communication. Students can be invited to join a class through a private code, or automatically imported from a school domain. Teachers can create, distribute and mark assignments all within the Google ecosystem. Each class creates a separate folder in the respective user's Drive, where the student can submit work to be graded by a teacher. Assignments and due dates are added to Google calendar, each assignment can belong to a category (or topic). Teachers can monitor the progress for each student by reviewing revision history of a document, and after being graded, teachers can return work along with comments and grades.

Moodle: Moodle is a scalable and customizable open-source learning-management system. It features blended learning, classroom management, built-in course authoring, mobile learning, both asynchronous and synchronous learning, certification management, social learning, video conferencing and more. It also supports gamification to make learning fun and can be adapted to corporate and business applications, though it is mainly marketed to educational institutions. Because it's open source, it's completely free to use on school's own servers. Moodle offers support through a selection of partners offering help through consulting, training, theme design, development and maintenance to ensure that schools and educators get the most out of it.

Tencent classroom: Based in China, Tencent Cloud provides comprehensive solutions for various educational scenarios to quickly build up online learning platforms while saving costs. The company offers an end-to-end solution to digitally transform curriculum and build online education platform from the ground up, or various digital tools and services that can complement existing platforms to enhance the quality of interactive online education.

Classroom.cloud: Classroom.cloud platform is designed for effective classroom management and teaching, whether everyone is together in the classroom or learning remotely at home. With no swapping between solutions for the different scenarios, it is designed to provide continuity for students – and teachers too. The platform provides a range of tools that help teachers manage and control online class behaviour (helping to keep students focused and on task), plus a set of simple yet effective teaching tools to support engaging and meaningful learning experiences.

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