

# Digital Pathways for Education: Enabling Greater Impact for All

Subhashini Rajasekaran, Taskeen Adam, and Klaus Tilmes





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## Acknowledgements

This book has been prepared by a core team led by Subhashini Rajasekaran (Education Specialist, World Bank) and comprising Taskeen Adams (Co-Director, Open Development Education) and Klaus Tilmes (Senior Policy Adviser on emerging technologies and development). It has been prepared under the direction of Rita Almeida (Practice Manager for Education Global Practice) and Jamele Rigolini (Lead Economist for Human Development, Europe and Central Asia region) and support from Ahmet Levent Yener (Practice Leader for Human Development, South Caucasus) and Jamexis Denise Christian (Senior Operations Officer, Human Development, Europe and Central Asia).

The review of evidence is based on work done in collaboration with Taskeen Adams, and Klaus Tilmes. The team received valuable inputs from Robert Hawkins, Senior Education Specialist and Global Lead for Education, Technology, and Innovation. Michael Trucano, Visiting Fellow, Brookings (previously, Global Lead for Technology & Innovation in Education, World Bank) played a vital role in encouraging, advising, and providing early comments.

The book has immensely benefited from inputs and case examples from Husein Abdul-Hamid, Bjorn Hassler, Adrien Samuel Julien Olszak Olszewski, Kristel Rillo, and Ravi Gupta, as well as editorial support from the World Bank Chennai Office and Fiona Mackintosh. The team is grateful for research assistance from Kexin Wang, Education Consultant, and for program assistance from Renata Pereira De Mello, Tania Fragnaud, and Hala Bishara.

The team would like to thank World Bank colleagues and peer reviewers Alex Twinomugisha, Cristobal Cobo, Gabriel Demombynes, Husein Abdul-Hamid, Noah Yarrow, Sachiko Kataoka, Simon Carl O'Meally and Shobhana Sosale for the advice and guidance provided that contributed to the development of this work. The team would furthermore like to thank Stéphan Vincent-Lancrin (OECD), Karl Rectanus (previously Instructure), Natalia Kucirkova (University of Stavanger, Norway), Velislava Hillman (London School of Economics), Gouri Gupta (Director EdTech, Central Square Foundation, India), Michael Forshaw (Founder, Edtech Impact, UK), Daniel Stanhope (Founding Researcher, Learn-Platform by Instructure) and many others who have shared their reflections related to evidence and risks and provided insights from implementation experience in a wide range of policy environments globally.

The team benefited from valuable consultations with a variety of stakeholders including many senior policymakers from the Europe and Central Asia region, Africa region and East and South East Asia region between 2023 and 2024, including as part of the Cambridge HP Edtech Fellowship. This helped gather valuable insights on relevance and use of the framework to inform their strategy and implementation related to the digital area in education. The team is indebted to all counterparts for their valuable reflections, insights, questions and, for their passion to address the learning and education needs of their countries and regions. These have significantly contributed to strengthen the discussions on the digital pathways in education framework and the digital readiness assessments.

We are immensely thankful for the strong encouragement, support and overall guidance from Michal Rutkowski, Regional Director for Human Development, Europe and Central Asia region; Luis Benveniste, Global Director for Education Global Practice; and Jaime Saavedra, Regional Director for Human Development, Latin America and the Caribbean.

This product is part of a task under the Human Development Assessments in Eastern Neighborhood Countries (Pr73530). This work could not have come to life without the generous funding from the Trust Fund Program EU2020 Knowledge & Advisory Services (EU2020) of the European Commission's Directorate General for Neighborhood and Enlargement Negotiations (DG NEAR).

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Throughout this book, all references made to specific commercial digital products, services, enterprises, and entities are intended to provide relevant and real-life examples to demonstrate the available solutions and clarify the related messages. None of the references signify an endorsement of the said products, solutions, or enterprises. The authors, as well as the World Bank, act as neutral arbiters of knowledge to help identify both opportunities and risks for improving education outcomes.

# Abbreviations

<b>AGI</b>	Artificial General Intelligence
<b>AI</b>	Artificial Intelligence
<b>AIEd</b>	AI in Education
<b>AR</b>	Augmented Reality
<b>AWS</b>	Amazon Web Services
<b>BESA</b>	British Educational Suppliers Association
<b>CoP</b>	Communities of Practice
<b>CRIA</b>	Child Rights Impact Assessment
<b>CRM</b>	Customer Relationship Management
<b>CRRE</b>	Center for Research and Reform in Education
<b>CSO</b>	Civil Society Organization
<b>CxO</b>	Chief X Officer (C-Suite Designation)
<b>DBE</b>	Department of Basic Education
<b>DCC</b>	Digital Credentials Consortium
<b>DLP</b>	Digital Literacy Program
<b>DSP</b>	Digital Service Provider
<b>EDRA</b>	Education's Digital Readiness Assessment
<b>EEF</b>	Equitable Education Fund
<b>EHIS</b>	Estonian Education Information System
<b>EiE</b>	Education in Emergency
<b>EMIS</b>	Educational Management Information System
<b>ERP</b>	Enterprise Resource Planning
<b>ESL</b>	Early School Leaving
<b>ESSA</b>	Every Student Succeeds Act
<b>EU</b>	European Union
<b>EWM</b>	Early Warning Mechanism
<b>EVER</b>	Evidence Evaluation Routine
<b>FCV</b>	Fragility, Conflict and Violence
<b>GDPR</b>	General Data Protection Regulation
<b>GIS</b>	Geographic Information System
<b>GRM</b>	Grievance Redress Mechanism
<b>GTCI</b>	Global Talent Competitiveness Index
<b>HEMIS</b>	Higher Education Management Information System
<b>HIC</b>	High-Income Country
<b>ICT</b>	Information and Communication Technology
<b>IFI</b>	International Financial Institution
<b>IFOW</b>	Institute for Future of Work
<b>IoT</b>	Internet of Things
<b>IP</b>	Intellectual Property
<b>IRI</b>	Interactive Radio Instruction
<b>ITS</b>	Intelligent Tutoring Systems
<b>IVR</b>	Interactive Voice Response

<b>LAYS</b>	Learning-Adjusted Years of Schooling
<b>LIC</b>	Low-Income Country
<b>LMIC</b>	Lower-Middle-Income Country
<b>MIC</b>	Middle-Income Country
<b>MINTIC</b>	Ministry of Information Technologies and Communications
<b>MOE</b>	Ministry of Education
<b>MOOC</b>	Massive Open Online Course
<b>MOST</b>	Multiphase Optimization Strategy
<b>MR</b>	Mixed Reality
<b>NDEAR</b>	National Digital Education Architecture
<b>NEET</b>	Not in Education, Employment or Training
<b>NEP</b>	National Education Plan
<b>NERN</b>	National Education and Research Network
<b>NIA</b>	National Information Society Agency
<b>NLP</b>	Natural Language Processing
<b>OCR</b>	Optical Character Recognition
<b>OECD</b>	Organization for Economic Co-operation and Development
<b>OER</b>	Open Educational Resources
<b>OOS</b>	Out-of-School
<b>PAL</b>	Personalized Adaptive Learning
<b>PLN</b>	Professional Learning Network
<b>PPP</b>	Public-Private Partnership
<b>RCT</b>	Randomized Control Trial
<b>RFP</b>	Request for Procurement
<b>RLH</b>	Regional Learning Hub
<b>SD</b>	Standard Deviation
<b>SMART</b>	Sequential Multiple Assigned Randomized Trials
<b>SMEs</b>	Small and Medium Enterprises
<b>SMMR</b>	Systematic Mixed Methods Research
<b>SND</b>	Special Needs and Disabilities
<b>SSAMS</b>	Sudan Schools Attendance Monitoring System
<b>STEM</b>	Science, Technology, Engineering, and Math
<b>TCO</b>	Total Cost of Ownership
<b>TVET</b>	Technical and Vocational Education and Training
<b>TPD</b>	Teacher Professional Development
<b>UNESCO</b>	United Nations Educational, Scientific and Cultural Organization
<b>UNICEF</b>	United Nations Children's Fund
<b>USAID</b>	United States Agency for International Development
<b>VPLN</b>	Virtual and Global Professional Learning Network
<b>VR</b>	Virtual Reality



## Key Terms

**Digitization of the education system** refers to the process of converting physical objects into a digital format. Digitizing paper-based education data and document scanning are relevant examples. In these processes, text extracted from physical paper is converted to PDF or other digital formats, which are subsequently stored on the computer. Digitization organizes data into bits (units of information encoded into ones and zeros) that allow computers to process, store, and transmit analog data.<sup>1</sup>

**Digitalization** refers to converting analog processes to digital processes such as automating existing processes or retraining workers on using computers. Digitalizing education data in an educational management information system (EMIS) is an example. Digitalization goes further than digitization but does not yet use digital technology to introduce systemic or organizational changes.<sup>2</sup>

**Digital transformation** is the redesign of the education ecosystem, including its operational, organizational, and cultural aspects. It is complex, multicausal, and constantly evolving. It requires integrating digital technology and data into daily life and effectively managing the resulting changes that they bring about. Digital transformation requires the organizational system to evaluate, reengineer, and reimagine its functions and strategic outcomes. An example is ensuring digitally and data-enabled decision-making in education at all levels using feedback loops. Such agility will facilitate ongoing digitalization initiatives but should not be confused with them. There is no well-defined endpoint for a digital transformation, which involves continuous improvement by default.

**Digital transitions** refer to the advancements along a continuum with characteristic distinctions between analog, digitized, digitalized, and digitally transformed systems, with certain inflection points. For example, for countries/regions, this would mean considering who they are (context), what they want (ambition), why (rationale), where they are (readiness), and what they expect to achieve (results/outcomes) to clarify the digital transitions that may need to occur in the economy, in society and consequently in education, and what processes and pathways to follow and what related mechanisms are needed for governance.

**EdTech** refers to the private market and innovation ecosystem including universities, research institutions, nonprofits, start-ups, and enterprises that develop commercial products, applications, and services for educational and skills development stakeholders. These can include B2C (business to consumer), B2G (business to government), and B2B (business to business) products and services.

**Education interventions using digital solutions** refer to education policy, projects, and programmatic interventions that use digital solutions as part of the intervention design and/or business process redesign. These digital solutions may or may not use EdTech products and services. Making a distinction between EdTech and education interventions using digital solutions places the education-related outcomes and related interactions and processes at the center rather than the technology tools, products, and services.

# EXECUTIVE SUMMARY

## Background: Learning is in Crisis

**The world is being progressively propelled by technology and innovation, with education and skills development systems racing to keep up.** The possibilities of using digital solutions to enhance teaching and learning and to revolutionize educational processes are attractive, but the related investment needs are substantial in a fiscally constrained post-pandemic context, and evidence of effectiveness is scarce.<sup>i</sup> At the same time, there are growing concerns about the risks of these developments, including deepening digital inequalities, data privacy infringements, algorithmic discrimination, harmful surveillance, access to inappropriate content, online predators, health and well-being issues, fake news and misinformation, and cyberbullying.

**At the same time, the world is facing a longstanding global learning crisis with long-term adverse impacts on lifetime earnings, health and well-being.** This silent crisis is amplifying intergenerational poverty and inequities. Young people are not gaining equitable, relevant, and resilient knowledge, experience, and skills to prepare them for jobs, while a highly dynamic labor market increasingly exhibits skills mismatches. The results of PISA 2022 demonstrate extremely large deficits in foundational skills among students, including digital skills and creative thinking skills. This is particularly alarming considering the macro trends of rapid advancements in artificial intelligence (AI), rising life expectancy, and rising share of the working age population globally, indicating the need for quality learning and retraining opportunities at all ages to enable productive employment and civic participation throughout life.

**With the advent of AI, learning and work environments are going digital at an unprecedented speed and scale, but the demand for research evidence on technology use in education and skills development has just started to gain momentum.** The availability, affordability, and use of digital innovations in education (across formal, informal, and nonformal systems) have increased rapidly in recent years. Worldwide investment in EdTech companies is on an upswing, with global investment growing from US\$9.56 billion in 2017 to US\$25 billion in 2022.<sup>3</sup> Many more governments are advancing their digital investments

in education. However, these are often expensive, require adequate capacity, and consume a large share of public education budgets. Consequently, the need for robust research evidence is being felt much more strongly.

**Amidst these persistent and complex challenges, AI is revolutionizing education and skills development through its applications in computer vision, speech, machine learning, big data, and natural language processing.** Its rapid growth is reshaping interactions, communication, living, learning, and work. AI in education (AIEd) has the potential to power personalized learning, support teachers' understanding, and revolutionize educational practices by applying technologies such as intelligent tutoring systems (ITS), chatbots, and automated assessment to enhance learning, teaching, and administration. However, challenges persist, and its impact on education remains uncertain.<sup>4</sup> The pandemic and the global adoption of AI have further fueled longstanding debates, raising critical questions on issues of equity, ethics, and fairness.

**In these chaotic times of rapid technological advancements, huge learning gaps, high inequities, and fiscal constraints, passive, reactive, and fragmented education policy responses can deepen the learning crisis, leaving many young people behind.** Strong, proactive education leadership that leverages transformative ownership and a wide range of partnership engagements is needed to effectively adapt to a rapidly changing education and skills landscape. It is important to recognize the interconnectedness of learning and skills development with broader technological shifts as well as the critical need to achieve high-quality public benefits for all at affordable costs. A collaborative and iterative approach, deep contextual awareness, effective and adaptive leadership, and an evidence-informed roadmap is needed for steering digital transitions in education.

## What Should Education Leaders, Policymakers, and Practitioners Do?

**First, it is vital for education stakeholders to keep steady focus on the [vision](#)<sup>ii</sup> of providing equitable, relevant, and resilient learning for all.<sup>5</sup>** The science of learning tells us

<sup>i</sup> While efficacy trials of Edtech products and services show significant promise, measuring effectiveness of digitally enabled education intervention is more challenging and hence, scarce.

<sup>ii</sup> Learners are engaged - Teachers facilitate learning - Learning resources are adequate - Schools are safe and inclusive - Systems are well managed; with cross-cutting areas, Technology promotes learning - Home environments are supportive (World Bank, 2021).

**Figure ES1. Policy Actions to Realize an Equitable Future of Learning**



Source: Saavedra, J. C., et al (2020).

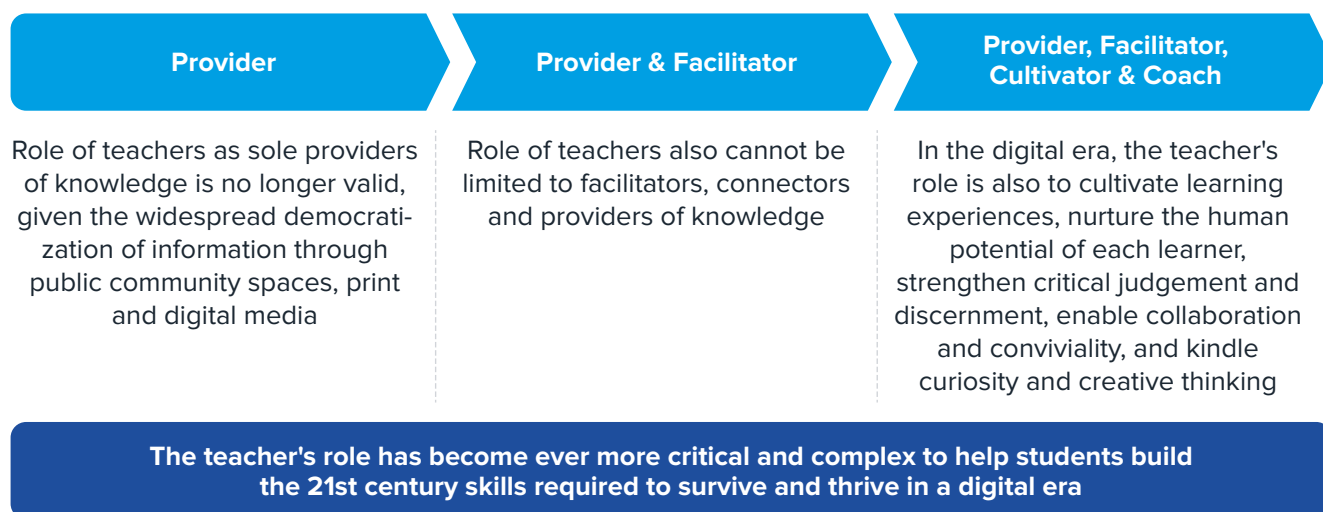
that learning needs to happen with joy, purpose, and rigor, for students to be engaged and motivated to learn. Such learning can happen for everyone, everywhere. But this can only be realized through a fundamental transformation of the different pillars of a robust education system: Learners are engaged, Teachers facilitate learning, Learning Resources are adequate, Schools are safe and inclusive, and Systems are well managed; with two crosscutting areas: Technology promotes Learning and Home Learning environments are supportive (World Bank, 2021). This can be accomplished by pursuing systemic reforms with a focus on equity and results, with commensurate and wise investments including in the use of technology (Figure ES1).

Second, as education races forward to keep pace with accelerating digital transformations, it is critical to recognize and support the changing role of teachers as cultivators, coaches, and critical pedagogues (Figure ES2). There has perhaps never been a more critical moment in

history than now to remind ourselves that learning, at its core, is about human connections—between students, teachers, parents, caregivers, managers, administrators, and broader communities—with teachers being the most significant mediators of learning.<sup>6</sup> More than two decades of research has shown that human learning occurs in the *interactions* between *learners* and *educators*, mediated by the learning environment (physical and digital) among other contextual factors.<sup>7</sup> Thus, it will be essential to safeguard the “learning core” by ensuring that the role of educators is expanded and altered as cultivators, coaches, and critical pedagogues.

Third, tailor digital pathways that can enable a systemic shift towards equitable, relevant and resilient education and skills development outcomes for all. Education systems can take on different digital pathways, from incremental, to progressive, to even a sea change, depending on the starting point and the prevailing circumstances.

**Figure ES2. Recognize and Support the Changing Role of Teachers**

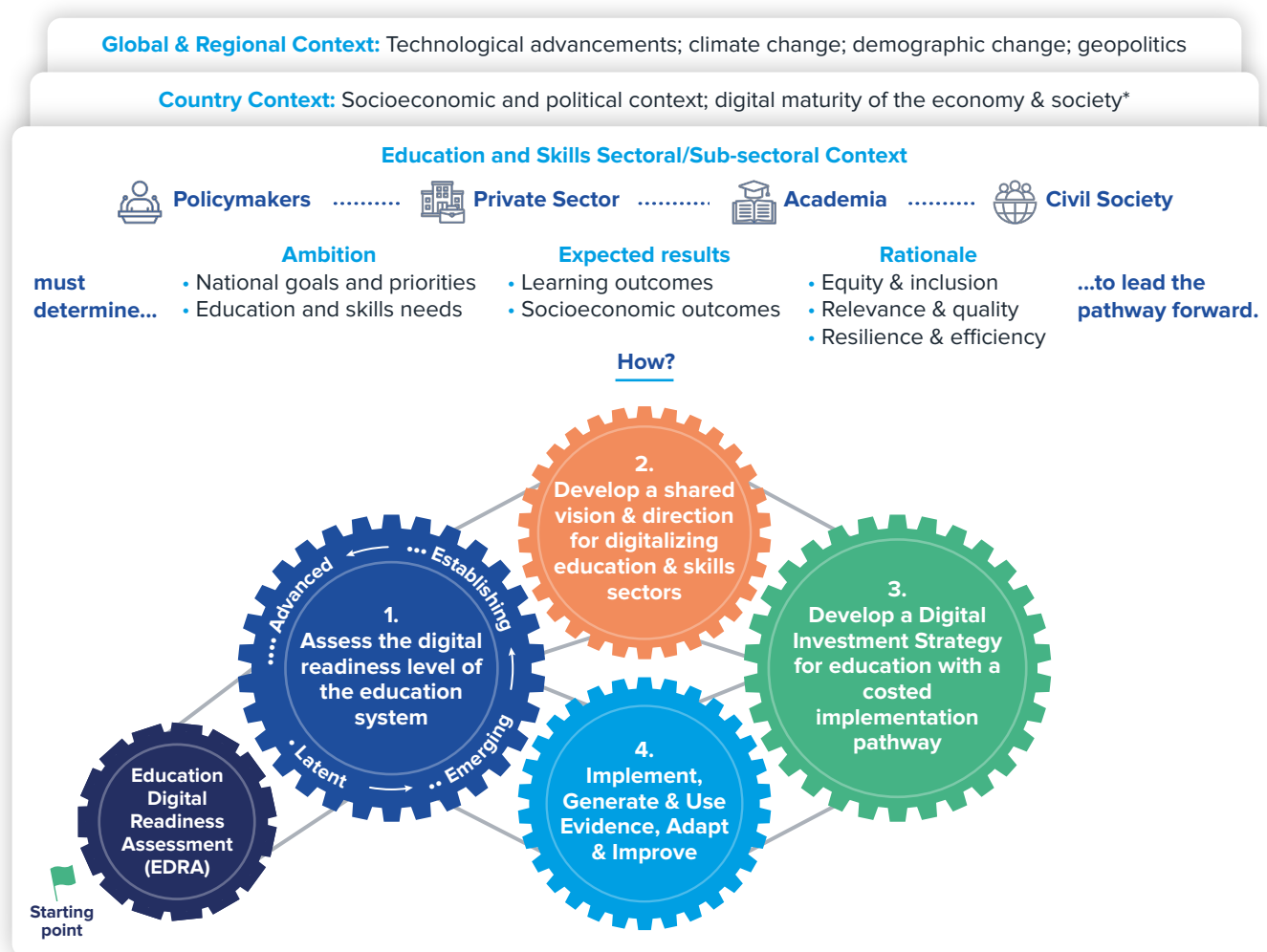


Source: Author's illustration.

Policymakers are best placed to astutely assess the determinant conditions and consider the policy tradeoffs, pitfalls, and effective practices for *tailoring* digital pathways for education. The potential digital pathways are often affected by global, regional and country contexts. Global and regional megatrends of technological advancements, climate change, demographic changes and geopolitics increasingly affect various facets of people's lives. At the same time, a country's sociopolitical and economic context plays a key role in determining suitable digital pathways. This includes considerations for demographics, social norms including gender norms, income distribution, national wealth, economic growth and productivity, political situation, stability and trust in government, access to capital and markets etc. The level of ambition related to national goals and priorities, as well as related education and skills needs often tend to be carefully con-

sidered. The rationale for education transformation, such as equity and inclusion goals, strengthening the quality and relevance of education, and improving the efficiency and resilience of the system are core drivers for coherent investments and focus on results. The potential digital pathways can then be based on the current state of digital readiness of the economy, society and the education system. Finally, results expected to be achieved play a determinant role in the pathways that need to be adopted ([Figure ES3](#)). For some countries, the transformation in education may seem far off, maybe even unattainable in the near future, yet a shared vision and policy direction can guide and inform systemic actions that policymakers can take now. [Chapter 4](#) and [Chapter 5](#) offer a detailed discussion on a range of issues pertinent across low-income, middle-income, and high-income country contexts.

**Figure ES3. Potential Digital Pathways for Equitable, Relevant and Resilient Education Systems**



Source: World Bank.

Notes: \* Country context may also include: demographics, gender, social norms, income distribution, national wealth, economic growth and productivity, political situation, stability and trust in government, access to capital and markets etc.

## How Can This Be Done: Enabling the Digital Transition of Education Systems

To achieve dramatically improved outcomes, it is important for policymakers and practitioners to embrace three mindset shifts to lead digital transitions proactively, strategically, and with an evidence-based approach (Figure ES4).

**1** *Shift from supporting short-term, ad hoc digital interventions to leading with a systemic, fit-for-purpose approach centered on learning and skills development.*

It is vital to take a coherent and collaborative systems approach when adopting digital pathways in education and skills development rather than a fragmented market-led reactive approach where digital solutions are mere add-ons. This can be done by promoting proactive learning-centered public policy measures and entering meaningful partnerships with industry and civil society. This includes deepening digital transitions in education by taking a systemic approach in the strategic governance, infrastructure, public policy design, and government implementation to improve education outcomes and scaling digital transitions in education with strong and learning-centered private markets and innovation ecosystems (including universities, research institutions, nonprofits, start-ups, and enterprises) to improve quality and equity and increase the efficiency, and relevance of education.

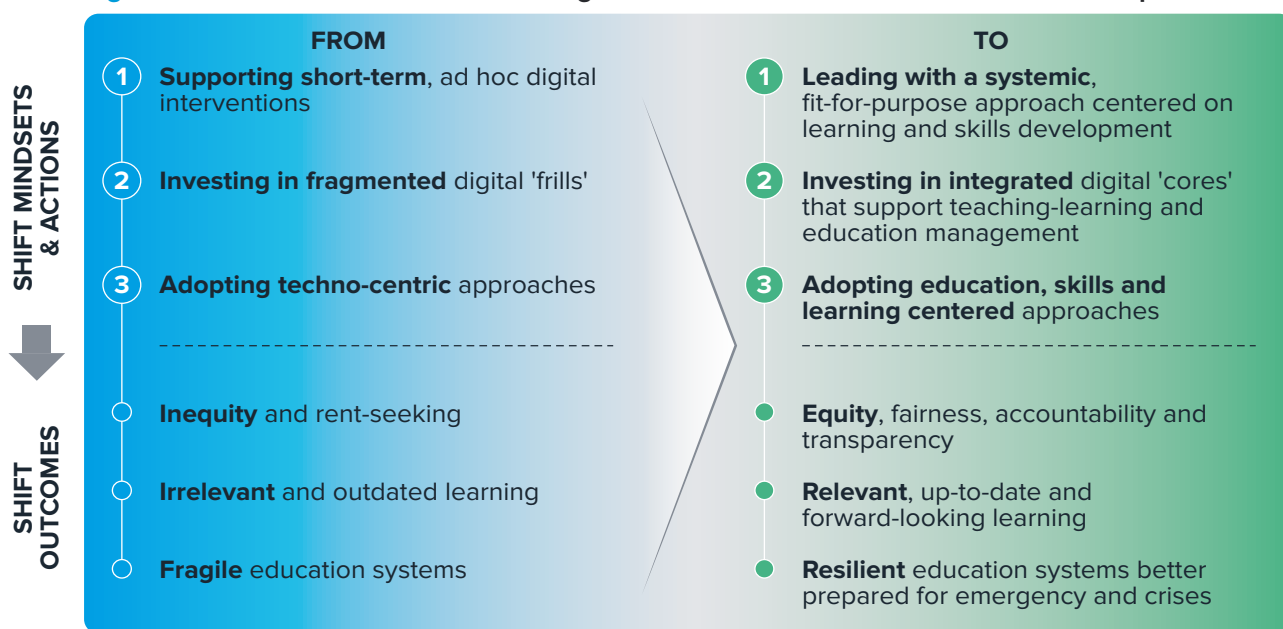
**2** *Shift from investing in fragmented digital “frills” to investing in integrated digital “core” that supports teaching, learning, and education management.*

Digital transitions in education require public policy and government implementation to shift from investments that increase fragmentation to those that drive system-wide embedded digital interventions. Investing in digital frills essentially means *ad hoc* investments in hardware, software, and content platforms with no cohesive results orientation. In contrast, investing in an integrated digital core implies coherence across strategic governance, partnerships, data and technology infrastructure, and implementation, which deepens the transition. This matters from the perspective of ensuring inclusion, security and privacy, and high-quality standards for all; enabling cost-efficiencies from economies of scale and scope; and generating and systematically embedding quality innovations with measurable effect sizes on learning.

**3** *Shift from adopting techno-centric approaches to adopting education, skills, and learning-centered approaches.*

Achieving equitable education impacts from digital transitions in education will require a shift from technocentric approaches towards learning-centered approaches. This often requires strong and robust inno-

**Figure ES4. Embrace Mindset Shifts in Digital Transitions in Education and Skills Development**



Source: Author's illustration.



vation ecosystems and private markets that are incentivized and supported to deliver contextualized, high-quality, and cost-effective educational products. The greater the extent to which education relies on private markets and innovations in universities, research institutions, non-profits, start-ups, and enterprises, the more potential for achieving the transition at scale. These engagements can provide educational institutions with emerging Edtech and AI based tools, foster competition, and drive demand at more affordable prices. At the same time, a comprehensive regulatory framework is essential to ensure equitable, high-quality education and skills development and encourage fair and healthy competition. Collaborative engagement between public policy and private markets is essential to support traditional and emerging education goals.

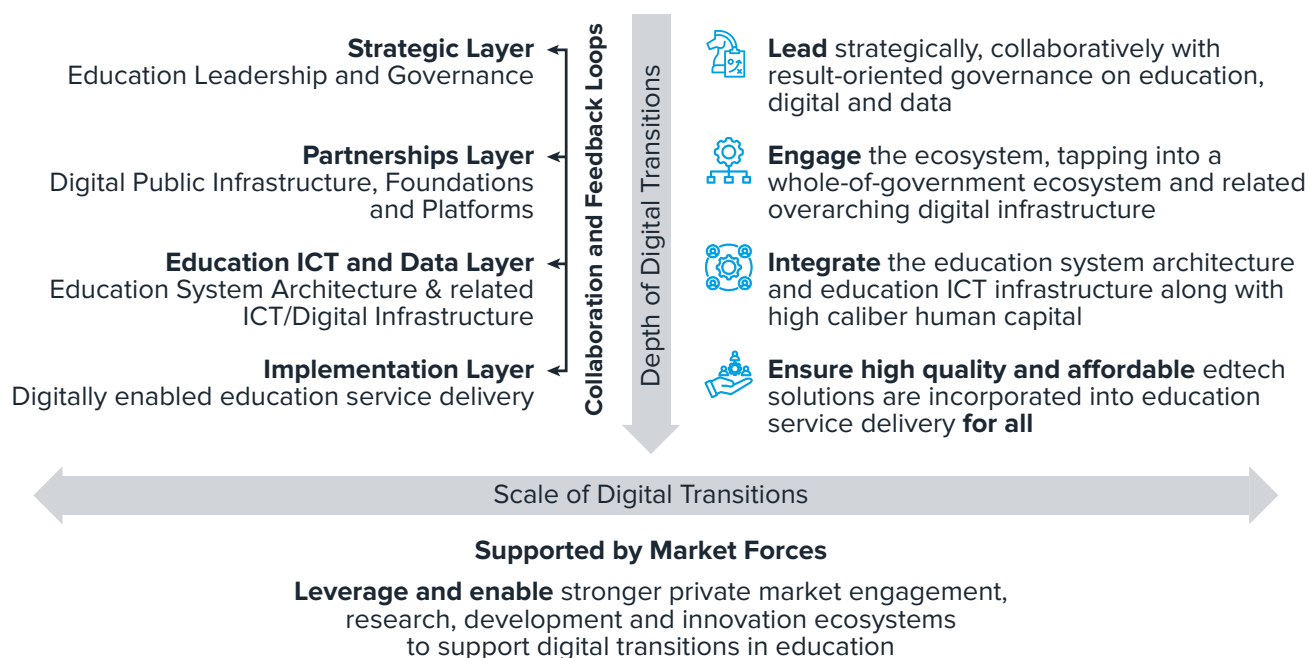
## Enabling Architecture for the Digital Transition of Education Systems

Overall, digital pathways in education and skills development can be seen as the interplay of two dimensions: **public policy along the vertical axis and market forces along the horizontal axis**. The digital arena of this interplay comprises at least four layers of the education ecosystem and an overarching transversal layer to scale digital with help of market forces, including research, CSOs, universities, and startups (Figure ES5). The topmost Strategic Layer of Education Leadership and Governance drives the digital agenda where high-priority bankable deci-

sions by education leadership show urgency and foster collaborative, result-oriented governance with a laser focus on learning. This layer drives close engagements between stakeholders under the Partnerships Layer for Digital Public Infrastructure, Foundations and Platforms to ensure appropriate coupling of education strategic plans with state digital programs. This is often enabled by university-industry collaboration, intra-government and inter-government partnerships, and other innovation ecosystems wherever useful and relevant. This is followed by the Education ICT and Data Layer comprising the Education System Architecture and related ICT/Digital Infrastructure driving, at its core, the data agenda and acting as a critical integration layer that glues together the other layers. The Implementation Layer is at the heart of the education endeavor—empowering learners, teachers, parents, and administrators toward the design and delivery of digitally enabled education services at scale for all.

This enabling architecture is crucial to: (i) **be more responsive to equity issues** ensuring fairness, accountability, and transparency in the face of a deep global learning crisis and very large numbers of people who are out-of-school and out-of-work; (ii) **be more relevant** to ensure that learning is up-to-date, and forward-looking, given the scale and speed of technological change, including AI; and (iii) **be more resilient** so that education systems are better prepared to ensure learning continuity in times of emergency and crises and of increasing climate-related shocks.

**Figure ES5. Enabling Architecture for the Digital Transition of Education Systems**



Source: Author's illustration.

## Digital Transitions Create Opportunities but also Risks

Countries that leverage digital solutions *can* realize equitable, relevant, and resilient education systems with a positive impact on learning outcomes *if* certain conditions are in place. One of these conditions is that the solutions are designed with the principles of learning in mind as well as the [principles of digital development](#)—such as inclusion, scale, and sustainability (Figure ES6).<sup>8</sup> This report outlines and reviews evidence on six potential outcomes of education that digital transitions can affect. While a growing number of evidence reviews have studied the impacts of digital interventions in education, their results have been mixed.<sup>9</sup> Some key findings are as follows:

- There are many practical challenges for generating robust evidence including contextualization, intervention complexity often including several confounding variables, the need for iterative evaluation design approaches, combined with the cost and time taken for rigorous evaluations.
- It is vital to embrace plurality of evidence on digitally enabled education interventions. These must go beyond “what works” to address questions of “how,” “why,” “under what conditions,” and “for whom.”

- Stronger policy commitments are needed to generate and use evidence such as adopting a hierarchy of evidence methods and embracing newer methods of generating evidence for measuring additional affordances of digital solutions that improve education outcomes.

At the same time, the digital risk landscape for education systems is complex. Digital service providers (DSPs) and platform companies, whose business models rely on sustained user engagement, play a vital role in providing digital services in education and skills development. The terms of engagement in these services often increase digital exclusion, in addition to potentially exposing users to data privacy violations, online safety violations, threats to personal health and wellbeing, lax cybersecurity, AI-related risks, and the adverse effects of commercialization of education. There are also newly emerging risks often related to advanced technologies that policymakers need to keep abreast of and guard against. Some mitigation measures include building capacity at all levels of the education system for the responsible use of AI, the implementation of a regulatory framework, and the monitoring of algorithms. AI solutions, platforms, and tools are revolutionizing education by offering diverse capabilities but are also introducing novel risks and challenges for students, teachers, school leaders, and policymakers, particularly in terms of exacerbating exclusion, bias, and manipulation.

Figure ES6. Principles of Digital Development



Source: <https://digitalprinciples.org/endorsers/>



## Research: Shaping the Future of Evidence on the Use of Technology in Education

Research shows that technology can improve educational outcomes if certain conditions are put in place informed by learning sciences and digital development principles. However, literature has not kept pace with educational practice of technology use for teaching and learning and for pedagogical and administrative management. Some of the reasons for the significant lag between research and praxis include incoherence between speed and scale of technological advancements with regulation and research, challenge of generating timely, contextually relevant, and cost-effective research, and insufficient demand from policymakers for robust evidence on cost and quality.<sup>10</sup>

**But, with the fast-paced growth in the number and variety of EdTech solutions, tools, and platforms, it is challenging to identify quality.** Aspects of quality include the application of the science of learning, the safety of these tools, the ease with which these tools can connect with existing systems, their compliance with regulations and policies, their cost and eligibility for funding, and their impact on users. Policymakers and institutional managers often have to make rapid decisions regarding digital procurement and have to choose between a multitude of options. With no shared global standards of quality, their decisions may be influenced by advertising and business metrics than the potential learning impacts of the technology. Mislabeling digital products as educational can have serious negative ramifications for learning.

**Therefore, there is a need for a shared set of global quality assurance standards for digitally enabled educational products and services.** The EdTech markets are facing a problem with ‘lemons’<sup>11</sup> in which poor-quality products drive out better-quality ones because of information asymmetry, high proliferation of products and because no foolproof way exists to gauge quality before purchasing.<sup>iii</sup> In 2022, there were 455,000 ‘B2C educational’ apps in a predominantly unregulated and untested market. Hirsch-Pasek et al (2015) found that only a handful of apps are designed with an eye towards how children learn.<sup>12</sup>

**Embracing different methodologies is crucial for research on digital solutions in education.** Digital transitions in education involve various stages, including design, discovery, purchase decision, implementation, and application at scale. Research is lagging at all these stages, and traditional measures of the efficacy and effectiveness of the solutions are insufficient. The quality, equity, ethics, security, safety, and user experience for purported ‘educational’ digital solutions must be evaluated using independent expertise at different stages.

EdTech<sup>iv</sup> evidence is distinct from evidence on education interventions using digital solutions: **Definitions and terminologies matter in how evidence is generated, interpreted, and used.** Evidence on ‘education interventions utilizing digital solutions’ is not the same as evidence on ‘EdTech’. It is critical to distinguish between the assessment of an education intervention that involves the adoption, uptake, and use of digital solutions and the assessment of EdTech products that support market research and procurement decisions.

**Policymakers can establish a conducive regulatory environment for promoting and supporting the development of high-quality learning-centered products and services, requiring clear evidence at various stages of the innovation-adoption-scale-up cycle.** Research should be speedy, cost-effective, and scalable to produce the best outcomes. We propose that policymakers proceed with well-informed and qualified optimism<sup>13</sup> when allocating marginal investment dollars to the use of digital solutions in education. It is important to first assess their contextual needs, education objectives and digital readiness levels, in addition to the opportunity cost over analog solutions for making quality learning, upskilling, and reskilling accessible to everyone.

## Context Matters for Unlocking the Power of Digital for Education Transformation

**The readiness of a country to implement digitally enabled education services depends on important preconditions.** These include the country’s digital foundations such as high-speed affordable connectivity, digital identification and digital payment systems for individuals, communities, and societies to benefit more broadly. These also include digital enablers at the national and sectoral levels such as digital infrastructure, interoperable data infrastructures, digital skills and change management capacity, and innovation ecosystem, backed by relevant policies and regulations. Together, these enable systemic digitalization of education service delivery at scale.

**Systemic assessment of a country’s readiness for using digital solutions in education is crucial for effective change management and for guiding digital transformation efforts.** Such readiness assessment enables policymakers to objectively consider different scenarios and international best practices as well as to identify and prioritize actions that can ensure that policies are relevant for today and remain resilient to future challenges. Moreover, there is a significant danger of continuing and worsening inequities, because of less mature foundational capabilities and digital enablers in lower-income and lower middle-income countries compared to the upper-middle income and high-income countries.

<sup>iii</sup> ‘The problem with lemons’ is outlined in George Akerlof’s 1970 paper on the effect of quality uncertainty on the market mechanism.

<sup>iv</sup> EdTech refers to the private market and innovation ecosystem that develops commercial products, applications, and services for educational and skills development stakeholders. These can include, for example, B2C, B2G, B2B products and services. Whereas education interventions using digital solutions refer to education policy, projects, and programmatic interventions that employ digital solutions as part of the intervention design and/or business process redesign. These digital solutions may or may not employ commercial EdTech products and services. Clarifying this terminology helps to place the education-related outcomes and related interaction processes at the center rather than the technology product/service at the center.

**Policymakers must ensure that the digital transition in education has a focus on equity and rights.** Different pathways can be taken depending on the needs and context of each country. The digital maturity of an economy is highly correlated with per capita income: the more mature and diversified an economy or ecosystem is, the likelier it is to have the requisite infrastructure, institutions, regulations, and human capital for the transition.<sup>14</sup> Thus, public investments must focus on the needs of marginalized groups (such as children, young people, women, people with disabilities, minority groups, and marginalized communities).

**The readiness of education systems for digital transitions relies on at least five essential pillars:** (i) strategic leadership and governance; (ii) data and technology infrastructure; (iii) digitally enabled education service delivery and analytics; (iv) an education workforce with the necessary capacity and culture; and (v) the existence of an EdTech market and business models. Each of these pillars plays a crucial role in shaping a country's digital pathways and together provide a comprehensive framework for informed decision-making. Understanding this readiness level helps inform a country's preparedness for successful digital transition in its education system.<sup>15</sup>

**Assessing the digital readiness of education and skills development systems is crucial for informing government strategies and action plans.** It encourages ecosystem actors to align their approaches with national education and skills development goals and priorities. Evaluating a system's readiness provides insights into its infrastructure, governance, capacity, core education services, and market structures. It also considers how a country's overall digital approach is supporting high-quality education and skills development. Such an assessment should take a comprehensive approach to identifying critical systemic barriers (such as a lack of capacity or coordination) that may not be directly visible or under the remit of the Ministry of Education.

**The experiences of Moldova, Georgia, and Kosovo in the ECA region demonstrate how a systemic assessment of digital readiness can glean prioritized recommendations and nuanced actions for advancing education objectives in a particular context.**<sup>16</sup> The assessment must consider first the country's broader national objectives and digital maturity and the education sector's challenges and priorities and then use these findings to assess where and in what ways the country could leverage digital solutions to advance education outcomes. By triangulating various data sources and stakeholder mapping, the assessment can offer recommendations to enhance foundational, functional, and frontier digital capabilities, aiming to stimulate action and dialogue on the development of a transition roadmap for education. Stakeholder

mapping and engagement at all levels enhance the success of digital transition initiatives ([Chapter 4, Figure 16](#)).

## Tailoring Digital Pathways – Tradeoffs, Common Pitfalls, and Effective Practices

**Each country's vision for its economy, society, and education will drive the digital pathways that it adopts.** There are three ways in which digital transitions in education can mature and scale: (i) the overall digital ecosystem sets the pace, with education gradually incorporating digital resources; (ii) disruptive events or initiatives pressure education improvements, such as the pandemic accelerating digitalization efforts; or (iii) the education sector takes the lead, supported by the digital ecosystem. The third path is most sustainable, as has been seen in country experiences such as Singapore, Estonia, South Korea and many others.

**It is crucial to tailor digital pathways to the country context in education and skills development, with a keen focus on equity considerations.** This involves adjusting strategies and incorporating digital technologies to meet education objectives with a firm focus on inclusion, relevance, and resilience. Educational policies must align and potentially strengthen the broader policy environment, in acknowledgment of their impact on education outcomes. It is important to consider stakeholder perspectives carefully and create responsive policies for optimizing digital transformation benefits and minimizing challenges during policy implementation.

**Policymakers face formidable and multifaceted challenges, including financial considerations, when deploying digitally enabled education.** In many countries where economic constraints are huge and public investment is at a premium, large upfront investment needed for digital transformation is a formidable challenge to overcome.<sup>17</sup> Policymakers may need to strike a delicate balance between innovations, strategic scaling plans, and the dynamic education environment. Finding and sustaining along a strategic digital pathway should involve both short-term and long-term policies, as well as the capacity to adapt to social, technological, and economic shifts.

**Moreover, policymakers often have to grapple with critical trade-offs in shaping digital transitions in education and skills development systems.** The journey to embed risk-informed digital approaches throughout an education system requires careful consideration of trade-offs related to the starting point, desired destination, and the "collective" ability of stakeholders to successfully manage change processes. These can lead to incremental, progressive, or transformative impacts, depending on the context. For example, an SMS-based tutoring guide might be trans-

formative in an FCV country but might be only considered a digital frill in another.

**It is pivotal to balance realism with aspirational strategies, ensure durability of policies, and prioritize educational needs through careful resource allocation.** This will promote the effective design and implementation of digitally enabled education policy. The report identifies and discusses key trade-offs related to the influence of governance structures, the implications of data sharing, data privacy and cybersecurity challenges, procurement strategies, coordination costs, the role of champions on effective and systemic use of digital in education, and collaboration with authorities from other sectors.

**While all countries and regions must pave their own digital pathways in education, they can learn from the common pitfalls encountered by and effective practices used in other countries.** Learning from experiences avoids reinventing the wheel. Yet caution is needed when aspiring to adopt and implement digital policies of countries that may have a more developed environment, and may not share similar contexts, while also balancing benefits against risks.

**Partnerships between governments, international financial institutions (IFIs), the private sector, philanthropists, and civil society are crucial for ensuring an equitable, relevant, and resilient digital future in education.**<sup>18</sup> Digital inclusion and social inclusion are intricately and directly enmeshed and require adaptive, responsive, and timely public policy interventions. Inaction or a reactive approach is not viable as technology, platforms, and underlying data industry are not value neutral. Data, in particular, is a critical frontier for all digital transitions, including education. Multisectoral investments are needed in electricity, foundational and shared public digital infrastructure, and “meaningful” connectivity,<sup>v, 19</sup> while for digitalizing the education system architecture, it is vital to leverage people, data, and technology.

**Each country needs to develop a strategic vision for digitally enabled education and skills development,**

**supported by concrete funding, governance, and implementation arrangements.**<sup>vi</sup> When decision-makers rely on political considerations or the reputation of EdTech innovations supersedes evidence and good practices, this is often a recipe for failure. At the same time, when decision-makers seek evidence, challenges still abound, particularly the difficulty of finding relevant and applicable research as these often maybe outdated, complex, and not independently reviewed. Bridging this gap with accessible and high-quality research is essential to navigate the exponential growth of EdTech innovations and ensure that evidence plays a central role in shaping education systems fit for the digital age.

## Outline of the Book

This book presents a conceptual framework followed by a discussion of global evidence on the opportunities and risks of going digital, the contextual preconditions, and how digital pathways can be tailored to produce greater educational impact at scale for all. [Chapter 1](#) provides important background that sets the stage for the conceptual framework and clarifies the motivation and purpose of this work. [Chapter 2](#) discusses the elements of the conceptual framework, expanding on the systemic role played by digital solutions in the delivery of education services to enhance inclusion, resilience, and effectiveness. [Chapter 3](#) identifies potential benefits and risks of digital transitions in education, mapping the mixed evidence base and highlighting opportunities and mitigation measures. It also offers an elaborate discussion to shape the future of evidence. [Chapter 4](#) discusses the underlying contextual conditions that underpin the conceptual framework and can enable the large-scale design, implementation, and use of digital solutions in education systems. [Chapter 5](#) discusses how governments and policymakers can think about tailoring pathways for digital transitions in education and skills development to inform short-term, medium-term, and long-term policy and implementation measures, including trade-off considerations as well as common pitfalls and effective practices. [Chapter 6](#) offers a concluding statement.

**Table ES1. Tailoring Digital Pathways: Effective Practices and Common Pitfalls**

Effective practices	Common pitfalls
<ul style="list-style-type: none"> <li>• Ensure a high degree of coordination and coherence between and across policies</li> <li>• Use agile approaches</li> <li>• Begin with the problem(s)</li> <li>• Align education sector plans and ICT infrastructure</li> <li>• Design for scale</li> <li>• Establish collaborative systems</li> <li>• Incorporate flexibility and adaptability</li> <li>• Focus on the usability of data systems</li> <li>• Learn from other industries</li> </ul>	<ul style="list-style-type: none"> <li>• Device- or technology-centric strategies and procurement</li> <li>• Not considering opportunity costs</li> <li>• Inflexible, long-term plans</li> <li>• Inadequate government support</li> <li>• Lack of stakeholder buy-in</li> <li>• Coordination issues</li> <li>• Disjointed legacy systems</li> <li>• Data privacy and security</li> </ul>

<sup>v</sup> The meaningful connectivity target is a tool to raise the bar for internet access and set more ambitious policy goals for digital development. It sets minimum thresholds across the four dimensions of internet access that matter most to users. These are (a) regular internet use | minimum threshold: daily use; (b) an appropriate device | minimum threshold: access to a smartphone; (c) Enough data | minimum threshold: an unlimited broadband connection at home or a place of work or study; and (d) a fast connection | minimum threshold: 4G mobile connectivity (A4AI, 2021).

<sup>vi</sup> OECD Directorate for Education and Skills (2023) Policies for the Digital Transformation of School Education: Proposed Analytical Framework and Methodology, at [https://one.oecd.org/document/EDU/EDPC/SR\(2023\)2/en/pdf](https://one.oecd.org/document/EDU/EDPC/SR(2023)2/en/pdf)



# 1 INTRODUCTION

**Learning and work environments are going digital at an unprecedented speed and scale.** The availability, affordability, and use of digital technologies in education, encompassing formal, informal, and nonformal settings, have grown rapidly in recent years in many countries. Recent groundbreaking technological advancements,<sup>vii</sup> such as artificial intelligence-enabled chatbots, encapsulate this growth and its pervasive effects on every aspect of education and work. Although the speed and scale of digital adoption and use in education vary across income groups, demographic groups, and contextual conditions, most education systems are increasingly leveraging digital solutions. The pandemic accelerated demand for emergency remote teaching modalities worldwide, exponentially catalyzing a widespread yet inequitable adoption of often piecemeal and fragmented digital solutions in education systems.<sup>20</sup> Furthermore, there are growing concerns about the risks accompanying digital solutions, such as data privacy infringements, algorithmic discrimination, harmful surveillance, access to inappropriate content, online predators, health and well-being issues, fake news and misinformation, and cyberbullying.

**At the same time, the world is facing a long-standing global learning crisis,<sup>viii</sup> which will likely have a long-term adverse impact on the lifetime earnings, health, and well-being of today's students, amplifying intergenerational poverty and inequities.** Many basic education systems are not fit for purpose,<sup>ix,21,22,23</sup> often exacerbating structural inequities,<sup>24</sup> and are insufficiently prepared to manage crises. While evidence consistently shows that the most effective education interventions rely on teachers and supportive school principals, in the vast majority of countries, they do not appear to have the skills needed to be effective.<sup>25</sup> Pandemic-driven school closures deepened the crisis, sharply increasing learning poverty<sup>x,26</sup> to an estimated 70 percent globally and exacerbating inequalities in education while exposing the deep digital divide.<sup>xi,27</sup> [UNICEF's 2022 Pulse Check](#) revealed that “one-third of nationally developed platforms have entirely shut down, are outdated, or are no longer fully functional, limiting

learning approaches to help schoolchildren recover their education.” Over 244 million children and young people are out of school,<sup>28</sup> and 468 million children lived in a conflict zone in 2023.<sup>29</sup> Education inequality is particularly shocking, with average education investment per student in the richest countries (US\$11,655) being 13 times higher than education spending in middle-income countries (MICs, US\$890) and 200 times higher than the spending in low-income countries (LICs, US\$56).<sup>30</sup> Globally, two-thirds of the world's school-age children or 1.3 billion children aged 3 to 17 years old do not have access to the internet at home, even though an overwhelming majority of digital innovations need devices with internet access and have limited compatibility with feature phones.<sup>31</sup>

**Young people are not gaining equitable, relevant, and resilient knowledge, experiences, and skills to prepare them for jobs of the present and the future, while skills mismatches are increasingly evident in a highly dynamic labor market.** The problem extends throughout formal, nonformal, and informal education and skills development from basic education to postsecondary, including vocational education, higher education, and lifelong learning. This is particularly concerning given the recent advances in artificial intelligence (AI), which are leading to changes in the skills required by employers. Moreover, the average job tenure is declining, and the gig economy offers new and flexible opportunities, especially in the informal labor market. These shifts require workers to constantly upskill and reskill in an increasingly digitally driven world. Furthermore, the high cost of higher education degrees and incongruent returns in the labor market, combined with several alternative ways to acquire credentials including short-term online courses and highly marketable certifications, are prompting many young people to sidestep formal postsecondary education. This is especially the case in industries that value skills over traditional formal credentials.<sup>32</sup> Finally, life expectancy continues to increase globally,<sup>xii</sup> and there is a rising share of working-age populations and those above the age of 65, indicating a need for quality learning and retraining opportunities to be

vii OpenAI's Generative AI-based chatbot software ChatGPT surpassed 1 million users in just five days of launch on November 30, 2022, growing 1,000 times to 1 billion users within 3 months.

viii The learning crisis has predated the COVID-19 pandemic, as new evidence has confirmed the alarmingly high learning poverty rates. According to the learning-adjusted data published in the joint report ‘The State of Global Learning Poverty: 2022 Update’, the average global learning poverty rate in lower-middle-income countries (LMICs) indicated that nearly 6 out of 10 children were not acquiring minimal literacy proficiency by the age of 10. Sub-Saharan Africa faced an even more critical situation, with 86 percent of children experiencing learning poverty in 2019.

ix According to the World Bank's State of Global Learning Poverty: 2022 Update, even before COVID-19, nearly 6 of every 10 children in LMICs could not read and understand a simple text by age 10. While the last few decades have seen a surge in school enrollment rates, 2017 statistics indicated that over 260 million young people across the world (ages 6 to 17 years) were out of school and at the peak of the COVID-19 pandemic, this reached 463 million (UNESCO 2017; UNICEF 2020). For those enrolled, the promise of education has not been realized: learning outcomes are low, schools are failing learners, and systems are failing schools (The World Bank 2018).

x Learning poverty means being unable to read and understand a simple text by age 10. The indicator combines the share of primary-age children out of school, who are defined as schooling deprived, and the share of pupils below a minimum proficiency in reading, who are defined as learning deprived. Thus, it is a combined measure of schooling and learning (World Bank 2022).

xi An abrupt and extensive transition to online only education, accompanied by disparities in digital infrastructure and access, exacerbated preexisting socioeconomic and digital divides. Remote learning failed to reach a minimum of 31 percent of students, equivalent to nearly half a billion students because of inadequate technological resources, unsuitable policies, or unsuitable technological infrastructure (UNESCO 2023).

xii Global life expectancy at birth reached 72.8 years in 2019, an increase of almost nine years since 1990.

available for people at all ages to enable them to engage in productive employment and civic participation throughout life.<sup>33</sup>

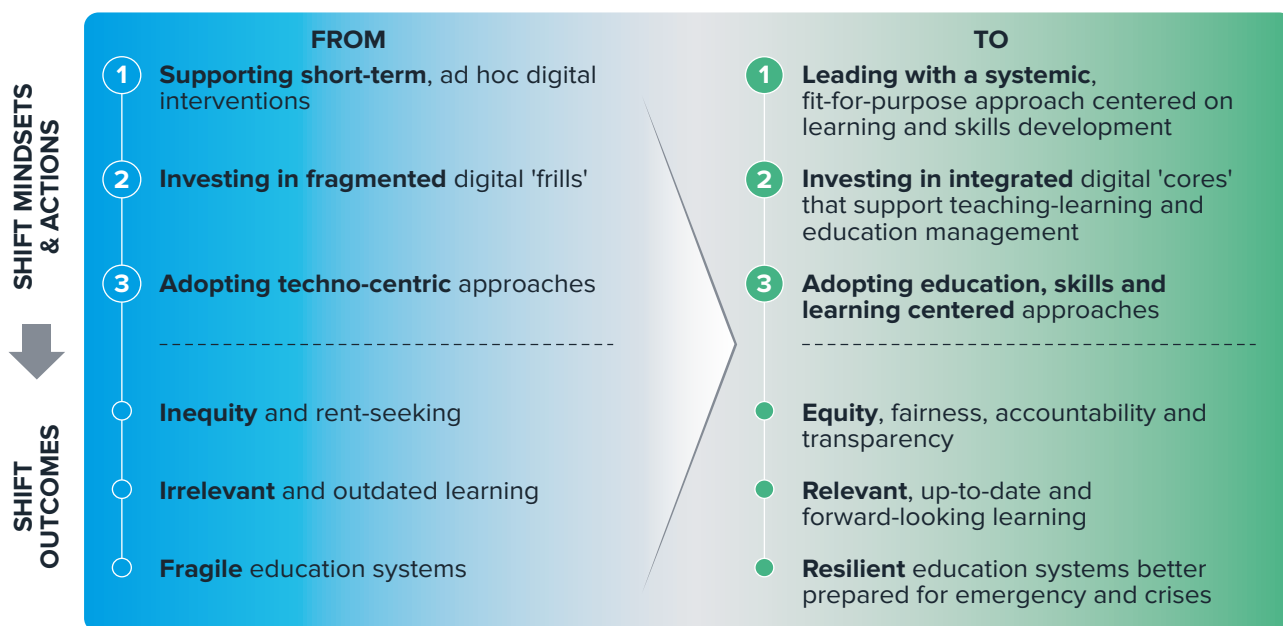
**Amidst these persistent challenges, education is expected to continue to experience digital transitions driven by the transformative wave from recent breakthroughs in AI.** AI encompasses computer vision, speech, machine learning, big data, and natural language processing (NLP) in enabling digital machines to perform tasks traditionally associated with intelligent beings. Its rapid growth is reshaping interactions, communication, living, learning, and work. AI in education (AIED) has the potential to offer personalized learning, enhance teachers' understanding of students, and revolutionize educational practices through the application of technologies such as intelligent tutoring systems (ITS), chatbots, and automated assessment. Despite AIED's promise, challenges persist, and its impact on education remains uncertain.<sup>34</sup> In the context of rapid changes and uncertainty, it is imperative to recognize the interconnectedness of learning and skills development with broader systemic shifts. Yet education systems cannot navigate these digital transitions in silos. Countries require a highly collaborative and iterative approach in manageable stages, a deep contextual awareness, effective leadership with transformative ownership, and an evidence-informed roadmap.

**Partnerships between governments, international financial institutions (IFIs), the private sector, philanthropists, and civil society are crucial for ensuring that digital transitions reduce rather than reinforce inequity, improve**

**the quality of learning, and increase its relevance, and strengthen the resilience and efficiency of education systems.** Digital inclusion and social inclusion are intricately and directly enmeshed and require adaptive, responsive, and timely public policy interventions. While the digital promise comes with perils,<sup>xiii,35,36,37</sup> neither non-action nor a reactive approach is an option—the technologies, platforms, and underlying data industry are not value-neutral. Data, in particular, is a critical frontier for all digital transitions, including education. Multisectoral investments are needed in electricity, foundational and shared public digital infrastructure, and “meaningful” connectivity<sup>xiv,38</sup> and in digitalizing the education system's architecture, leveraging people, data, and technology. Hence, policymakers, IFIs, and decision-makers need to take proactive measures to enable an inclusive, fit-for-purpose, and resilient digital future for education.<sup>39</sup>

**As education races forward to keep pace with accelerating digital transformations, what should education policymakers and practitioners do?** It is critical to remind ourselves that learning, at its core, is about human connections—between students, teachers, parents, caregivers, managers, administrators, and broader communities—and is largely mediated by the changing roles of teachers.<sup>40</sup> More than two decades of research has shown that learning occurs in the interactions between learners and educators, mediated by the learning environment (physical and digital) and affected by several contextual factors.<sup>41</sup> The capability of digital solutions (even AI-enabled humanlike interactions) can never fully replace the authenticity of sentient human interactions. There is a

**Figure 1. Key Shifts Required in Digital Transitions in Education and Skills Development**



Source: Author's illustration.

<sup>xiii</sup> The role of technology use in education has been a subject of intense debate for a long time. Promises of the past in the use and effectiveness of technology in education are still unrealized and expectations are muted. Research over the last 40 years in the use of technology in education shows that outcomes are mixed at best and cautionary at worst, including expensive failures such as the one-laptop-per-child programs (Facer and Selwyn 2021; Reich 2020; Ozler 2012).

<sup>xiv</sup> The meaningful connectivity target is a tool to raise the bar for internet access and set more ambitious policy goals for digital development. It sets minimum thresholds across the four dimensions of internet access that matter most to users. These are (a) regular internet use | minimum threshold: daily use; (b) an appropriate device | minimum threshold: access to a smartphone; (c) Enough data | minimum threshold: an unlimited broadband connection at home or a place of work or study; and (d) a fast connection | minimum threshold: 4G mobile connectivity (A4AI, 2021).

real risk that the widespread proliferation of digitally enabled learning solutions could lead to a price premium for learning with both human and technological interactions, while the poor may only be able to learn using technology. Therefore, it will be essential to safeguard the “learning core” by ensuring that the role of teachers and educators is expanded to encompass being cultivators, coaches, and critical pedagogues. When technology is harnessed in a spirit of well-informed and qualified optimism,<sup>42</sup> it may offer a potent opportunity to make quality learning, upskilling, and reskilling accessible to everyone.

**To be relevant, equitable, and resilient, it is important for the education and skills development policymakers to lead digital transitions proactively and strategically using an evidence-based approach (Figure 1).** Dramatic and urgent mindset shifts must be embraced and acted upon to achieve dramatically improved outcomes. The key shifts are as follows. Shift 1 involves moving away from short-term, *ad hoc* digital interventions to a fit-for-purpose, systemic approach centered on learning and skills development. Shift 2 involves moving away from investing in fragmented digital “frills” to investing in an integrated digital “core” that supports teaching-learning and education management. Shift 3 involves moving away from adopting technocentric approaches to adopting learning- and skills-centered approaches. These shifts would lead to better outcomes by moving from irrelevant and outdated learning to relevant, up-to-date and forward-looking learning approaches and materials, from inequity and rent seeking to equity, fairness, accountability, and transparency and by turning a fragile education system into a resilient system better prepared for emergency and crises. These shifts require an unwavering focus on learning impact, inclusion, and innovation combined with efforts to ensure cost-efficiency, privacy, and security.

**As inequities in inputs and outcomes continue to exist and grow between LICs, MICs, and HICs, developing tailored digital pathways and pursuing systemic reform efforts becomes even more important.** While on one hand, digitalization is driving innovation, economic growth, and job creation, generating positive spillovers in the broader economy of countries, the digital divide both within and between countries continues to widen, exacerbating poverty and productivity differences.<sup>43</sup> This affects LICs and MICs much more than HICs. Given that every country has its own unique, dynamic context and varied levels of digital maturity, undertaking deep systemic reforms may not be either easy or feasible in all contexts and situations. At the same time, digital technology is deeply embedded in learning, life, and work in HICs and many UMICs and is likely to become increasingly so in LICs and LMICs as digital foundations strengthen and technology advances into new markets. With this recognition, this work aims to

present ways in which countries can work towards being able to enact systemic approaches for education transformation enabled by digital technologies.

**Building on the World Bank’s education vision set out in [Realizing the Future of Learning](#),<sup>xv</sup>** The objective is to unpack the cross-cutting area “*Invest wisely in technology*,” looking into how this can be done to maximize impact at scale for all. Furthermore, emphasizing the human element at the core of learning, the report also draws from the World Bank’s Edtech approach paper “Reimagining Human Connections”<sup>44</sup>, aligning the conceptual framework presented in this work with the strategy’s five principles: (i) ask why; (ii) for all, at scale; (ii) empower teachers; (iv) engage the ecosystem; and (v) be data driven. The conceptual framework proposed in [Chapter 2](#) holds education goals of equity, relevance (quality, effectiveness, and efficiency), and resilience as central and the learning interaction and the teacher’s role as key determinants of outcomes. It focuses on how education systems can use digital solutions in a proactive, strategic, evidence-based manner to meet these goals at scale and with speed. It also offers a mental model to consider interactions between inward looking core education elements such as learners, teachers, resources, schools, home/parents, and systems, and outward looking interactions that have economy-wide impacts, including partnerships, ecosystems, and markets.

**This work offers a high-level strategic approach to undertaking the digital transition in education and skills development systems with a focus on “how” to make this happen.** We first present a conceptual framework followed by a discussion of global evidence on the opportunities and risks of going digital, the contextual preconditions, and how potential digital pathways can be tailored to lead to greater educational impact at scale for all. [Chapter 2](#) unpacks the elements of the conceptual framework, expanding on the systemic role of digital solutions in education service delivery to enhance inclusion, resilience, and effectiveness. [Chapter 3](#) identifies the potential benefits and risks of digital transitions in education, mapping the mixed evidence base and highlighting opportunities and mitigation measures. It also briefly examines the need for evidence methods and strategies that are responsive to digitally enabled education services. [Chapter 4](#) discusses the underlying contextual conditions that underpin the conceptual framework and can enable the large-scale design, implementation, and use of digital solutions in education systems. [Chapter 5](#) discusses how governments and policymakers can think about tailoring pathways for digital transitions in education and skills development to inform short-term, medium-term, and long-term policy and implementation measures, including trade-off considerations as well as common pitfalls and effective practices. [Chapter 6](#) offers a concluding statement.

<sup>xv</sup> Learners are engaged, Teachers facilitate learning, Learning Resources are adequate, Schools are safe and inclusive, and Systems are well managed; with crosscutting areas of Technology promotes Learning and Home Learning environment are supportive (World Bank, 2021).

# 2 ENABLING THE DIGITAL TRANSITION OF EDUCATION SYSTEMS: CONCEPTUAL FRAMEWORK

Today, the transition to digital in education and skills development must be seen as part of the broader, cross-sectoral technological transformation that is affecting the lives of all individuals and communities, both directly and indirectly. For example, the digital skills intensity<sup>xvi</sup> and related wage premiums in labor markets are increasing, and digital and social-emotional skills are a significant predictor of a person's ability to find and keep a job, to benefit from professional development, and to access civic engagement opportunities. This is because digital technologies have transversal applications, offering a growing array of affordances<sup>45,xvii</sup> such as transparency, customer centricity, adaptability, customizability, replicability, programmability, interoperability, and interactivity.

This 'anytime, anywhere' versatility of digital technologies enables them to be used in various ways to enhance learning environments and support learning continuity within and beyond institutions and across age groups. Beyond direct applications in teaching and learning, they are being used to strengthen pedagogical management, administrative management, and governance. In some countries, this is enabled by information systems and data analytics, and in a smaller group of countries, these are further interlinked with the country's whole-of-government digital foundations, infrastructure, and platforms. In some contexts, Ministries of Education are adopting a more strategic and systemic approach to use of digital solutions in collaboration with other ministries and relevant entities, while also taking steps to address risks such as deepening inequities and increasing security breaches.

## 2.1 Proposed Conceptual Framework

Education and skills development systems play a dual role: they enable digital transitions of economies *across sectors* by preparing and supplying skilled human resources in a rapidly changing labor market and, simultaneously, they themselves become digitally enabled to become more relevant, equitable, and resilient *across all education levels*. This chapter argues that, while every country will traverse its own unique digital trajectory in its attempt to get dramatically improved learning outcomes and build a strong human capital base, they must all embrace and act upon urgent and important mindset shifts. The chapter presents a conceptual framework for

enabling the digital transitions in education and skills development based on three key shifts:

*Shift 1. From supporting short-term, ad hoc digital interventions to leading with a systemic, fit-for-purpose approach centered on learning and skills development.*

There is an important distinction between digital pathways in education that take a coherent and collaborative systemic approach and those that take a fragmented and siloed approach when adopting digital solutions. A systems approach would entail using proactive public policy measures combined with meaningful market and civil society partnerships to enable effective innovations for scale. In the context of this report, two terms hold specific meaning:

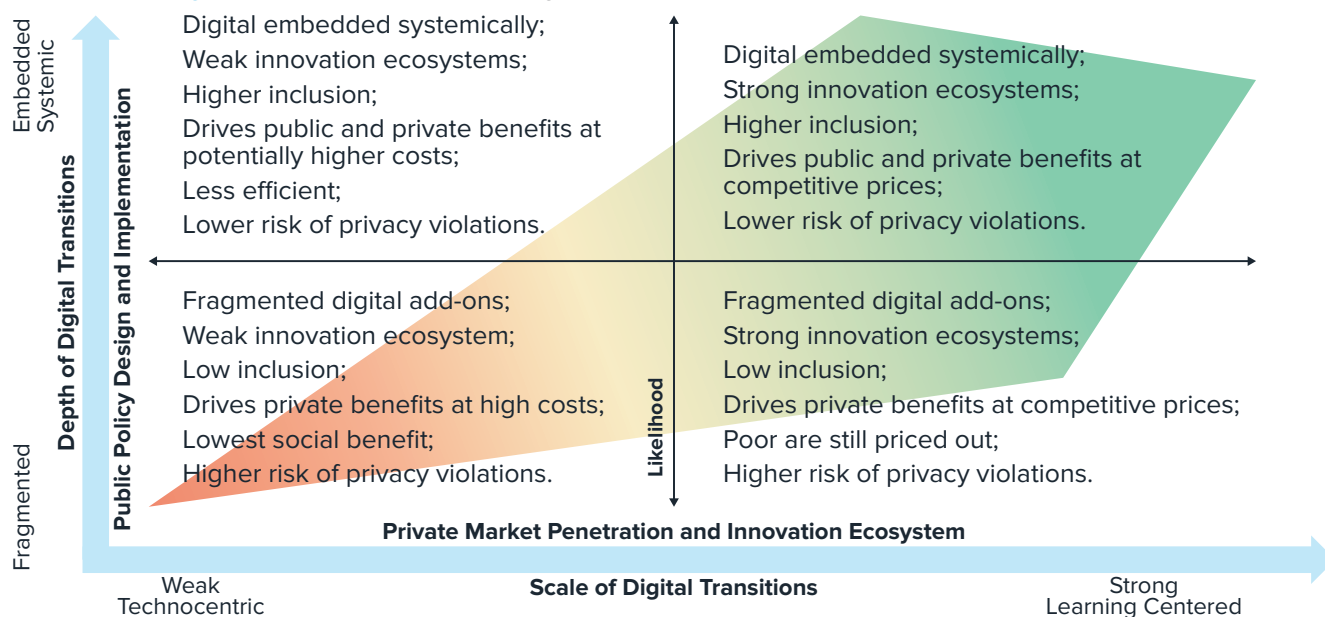
- **Deepening digital transitions in education or “depth”** refers to the extent to which digital transitions take a systemic approach in the strategic governance, infrastructure, policy design, and government-level implementation to improve the quality and equity and increase the efficiency, and relevance of education. This is represented along the vertical axis in [Figure 2](#).
- **Scaling digital transitions in education or “scale”** signifies the extent to which digital transitions are supported by strong and learning-centered private markets and innovation ecosystems (including universities, research institutions, nonprofits, start-ups, and enterprises) to improve the quality and equity and increase the efficiency and relevance of education. This is represented along the horizontal axis in [Figure 2](#).

When the education sector leads proactively and strategically supported by an education-friendly digital innovation ecosystem and when digital solutions are embedded and integrated as “core support” across the different levels, they are likely to strengthen and enhance the coherence and effectiveness of the core architecture of the education system. This will likely increase inclusion, efficiency, and relevance; improve quality; foster higher public and private benefits; ensure the sustainability of investments (for example, using national education data to identify and reengage vulnerable learners); and increase the resilience of the sector in the face of potential crises. At the same time, in the evolving educational landscape,

<sup>xvi</sup> How digitalised are the EU's enterprises? across all skills levels—basic, medium, and high skill jobs (Eurostat 2022). This is based on the Digital Intensity Index (DII), a composite indicator, derived from the survey on information and communication technology (ICT) usage and e-commerce in enterprises, which counts how many out of 12 selected technologies are used by each enterprise.

<sup>xvii</sup> Affordances are relationships between a physical or digital object and a person. They help determine how an object can be used but are not features.



**Figure 2. Depth and Scale of Digital Transitions in Education and Skills Development**

Source: Author's illustration.

private sector involvement is becoming a crucial input for governments who are increasingly dealing with disruption in the provision of education. Collaboration between public and private interests, with their respective complementary strengths, can expedite the digital transition in education systems. These alliances would need to leverage investments and professional knowledge while attracting innovative concepts and problem-solving capacity.

**However, in some cases, digital solutions are treated merely as add-ons and/or fragmented ways to enhance service delivery.** This tends to happen when education systems play an overwhelmingly passive or reactive role in response to technological advances (for example, increasing connectivity without a broader plan to ensure access) or when disruptive events (for example, COVID-19) or breakthroughs (for example, generative AI) create momentum for changes. Adopting digital solutions in such a fragmented way is less likely to improve learning outcomes and equity at scale, potentially causing learning outcomes to deteriorate and deepening inequity. Although there may be short-term benefits for limited user groups, these often come at high costs, leading to high private benefits and short-run investment horizons (for example, a large number of content platforms developed during the pandemic became defunct).<sup>xviii,46</sup> Figure 2 outlines the benefits of increasing the depth and scale of digital transitions.

**Shift 2. From investing in fragmented digital “frills” to investing in an integrated digital “core” that systemically supports teaching, learning, and education management.**

**Making a digital transition in the education sector requires public policy and government implementation to shift away from fragmented investments to those that are strategic and system wide.** Investing in digital frills means that investments in hardware, software, and content platforms (such as an SMS service, a digital content platform, or a data automation module) are made on an ad hoc basis in a piecemeal, uncoordinated fashion. Investing in an integrated digital core implies that the investments are made in a coherent way across strategic governance, data and technology infrastructure, policy design, and implementation. This deepens the digital transition, which is crucial to ensure inclusion, security, privacy, and high-quality standards for all. It also enables cost-efficiency and scale and makes it easier to generate evidence and systematically implement quality innovations that have measurable effects on learning. The proposed conceptual framework offers four layers of depth in the digital transitions of education systems:

- **Strategic Layer: Leading strategically with urgency and fostering collaborative, result-oriented governance with a laser focus on learning and on upskilling/reskilling outcomes.** For the deepest possible systemic impacts, strategic high priority decisions and actions by education leadership are fundamentally important. These include contextualized and adaptive management responsive to the country’s specific needs and to the fast-changing digital development landscape, policies and regulation, and institutional and public sector capacity development. Determining strategic priorities involves making important trade-offs (discussed in Chapter 5) and conducting an integrated digital risk assessment.

<sup>xviii</sup> The UNICEF (2022) Pulse Check revealed that “one-third of nationally developed platforms have entirely shut down, are outdated, or no longer fully functional, limiting learning approaches to help schoolchildren recover their education.”

- **Partnerships Layer: Establishing a whole-of-government ecosystem with shared digital public infrastructure, foundations, and platforms.** This is often done at the national government level and must be closely in sync with sector-level efforts. The whole-of-government ecosystem might include a single window procurement system, a secured intranet, and a data pipeline or service bus to disseminate and receive education-related information. When ICT systems specifically for the education sector are linked with these whole-of-government digital foundations, platforms, and infrastructure, the systems will be able to take better and data-informed decisions in harmony with other sectoral and national priorities. This ensures countrywide regulations are implemented by default and that education sectoral needs are coordinated and aligned with broader government initiatives and programs such as cloud infrastructure, AI laws, privacy laws, and telecom regulation. At the local level, citizens and stakeholders can be encouraged to engage in upskilling and reskilling through participatory digital tools. To enable all these developments, there is a critical need for sufficient human resources with adequate ICT/digital skills in government. The depth and scale of the systemic transformation of education would increase with greater digitalization of the system's architecture, information systems, and related human capabilities, especially when coupled with whole-of-government digital infrastructure and platforms. However, progress at the sectoral level will be hindered if the centralized and shared public digital infrastructure and governing institutions are not fit-for-purpose.
  - **Implementation Layer: Empowering learners, teachers, parents, and administrators to use digitally enabled education services at scale for all.** This is at the user/implementation unit level. It This may require digital interventions in learning and skills development with multichannel, multimodal affordances that can support teaching and learning as well as strengthen pedagogic and administrative management. At the school level, a wide array of tools for personalized learning, content development, formative assessments, budget planning, and procurements are available. B2C EdTech products and services are often used in this layer. However, the implementation success depends heavily on the maturity of private markets and innovation ecosystems in the country as well as its public governance and regulatory oversight. In low-capacity contexts with semi-centralized or fully centralized governance, the access to high-quality and cost-effective EdTech tools may vary widely among students, teachers, schools, and higher education institutions. Without a systematic approach, this fragmentation can compromise safety and prevent the benefits of economies of scale in procurement. On the other hand, a high level of fragmentation may still be effective in this layer for high-income contexts with highly decentralized governance, empowered schools and educators, and formal/informal learning collaboratives amongst educators.
- Shift 3. From adopting techno-centric approaches to adopting education, skills, and learning-centered approaches.**
- Policymakers working on digital transitions in education must shift from taking technocentric approaches to focusing on education, skills and learning-centered approaches, and to collaborating with strong and robust private markets and innovation ecosystems. In the context of this report, the term 'scale of digital transitions' refers to the extent to which the digital transitions in education rely on private markets and innovations from universities, research institutions, nonprofits, start-ups, and enterprises. These engagements and partnerships can provide the sector with new educational technologies and tools, as the recent surge in AI-based learning tools has illustrated. Countries with weaker private markets are likely to fall back or depend on imported and relatively expensive digital solutions for education that may often not meet the needs of the population (for example, when the national language is not widely used in digital formats). Such solutions may also fail to meet the country's regulatory norms (for example, outdated data offshoring and cybersecurity and safety policies) and infrastructure limits (for example, taxation on imports).

**Robust private markets, research investments, nonprofit organizations, and a digital innovation ecosystem can foster competition and drive demand at more affordable prices.** Private EdTech markets are a large and growing business frontier.<sup>xix,47</sup> Collaborative engagement between public policy and private markets is essential to support both traditional and emerging education goals and to experiment with novel approaches such as structured pedagogy, teaching at the right level, communities of learning, digital personalized learning, algorithms, and tele-coaching models. The resulting technologies, processes, systems, and programs can be developed to cater to all education sub-sectors (K-12, tertiary, technical and vocational education and training, corporate, and lifelong learning). This can be enabled through collaboration among various stakeholders, including private entities, public institutions, communities, and associations. The innovation and research ecosystem can provide governments with proof of concepts, guidelines for effective designs for scaling with quality, evidence from implementation efficacy trials, iterative improvements for ensuring greater fidelity and higher evaluation impacts and identify learning and innovation frontiers.

**While non-government participation brings evident benefits, a comprehensive regulatory framework is essential to ensure equitable and high-quality education and skills development, to encourage investment, and to foster healthy competition.** Governments should actively involve education stakeholders, including the private sector, in formulating policies, standards, strategic plans, and regulatory frameworks supported by robust regulatory mechanisms and quality assurance systems. Bilateral and multilateral funding agencies can promote public-private partnerships (PPPs), assist in the development of tools, and encourage responsible private sector investment in education, while emphasizing collaboration and partnerships.<sup>48</sup> Given the wide and increasing plethora of solutions, products, and services available, there is a need for substantial regulation and governance, partnerships, and multidisciplinary human capacity to translate between technological aspects and educational needs to navigate the risks and harness opportunities effectively within Ministries of Education and across government.

### ***Tying the Three Shifts Together in the Conceptual Framework***

The pathways towards a digital transition in education and skills development can be conceptualized as the interplay of two dimensions: public policy along the vertical axes and market forces along the horizontal axis (Figure 2). The depth dimension along the vertical axis indicates the design and implementation of public policy, moving from digital fragmentation to full systemic embeddedness. The scale dimension along the horizontal axis indicates the

range from weak and/or technocentric private markets and innovation ecosystems to strong and learning-centered private markets and innovation ecosystems.

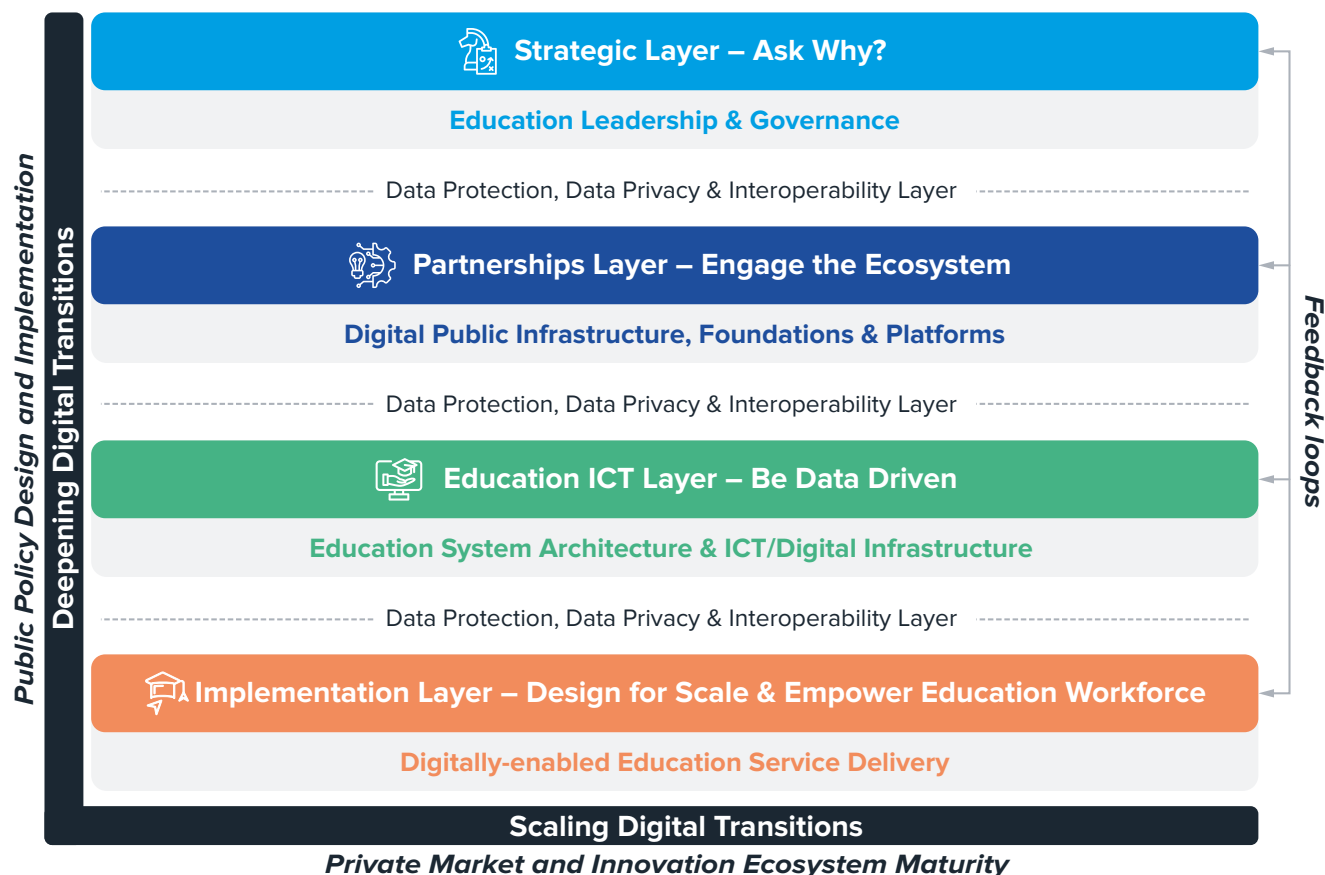
**The digital arena for this interplay between public policy and market forces can be thought of as a multi-plex—comprising at least four layers of the education ecosystem (Figure 3).**

- The topmost *Strategic Layer (Education Leadership and Governance)* drives the digital agenda. In this layer, policymakers must start by critically reflecting on if and why digital solutions are bankable strategies in the country in question and how best they can be adapted and used. These decisions are what should drive the close collaborations and engagements in the Partnerships Layer.
- The *Partnerships Layer (Digital Public Infrastructure, Foundations, and Platforms)* involves engaging the ecosystem of stakeholders across government, private sector, higher education, research, civil society, and importantly education service providers and beneficiaries (see also Chapter 4, Figure 16) to ensure appropriate coupling of education strategic plans with state digital programs and approaches.
- The *Education ICT and Data Layer (Education System Architecture and related ICT/Digital Infrastructure)* drives the data agenda. This is a critical integration layer that glues together the other layers. It operationalizes technology through provision, support, maintenance, monitoring, and capacity building for the Implementation Layer based on strategic foundations, while ensuring interlinkages with the developments in the broader ecosystem to benefit learning and skills development.
- The *Implementation Unit/User Layer* drives the heart of the education endeavor, which is learning, and skills development delivered by digitally enabled services. This involves designing for scale and ensuring that users—students, parents, teachers and guides, administrators, and job seekers—are empowered to learn and realize their human potential.

A data protection, privacy, and interoperability layer indicated between each of the above layers highlights the critical importance of safeguarding education data and personal data in a digitally enabled system. Furthermore, feedback loops established across and between these layers enhance the effectiveness, equity, transparency, and accountability of education processes. There is a clear tension between safeguarding data and sharing data, that is, between protecting data from misuse and enabling data interoperability and sharing for purposeful feedback, which must be managed and improved on a continuous basis.

<sup>xix</sup> The global investment in EdTech was estimated at US\$123.40 billion in 2022 (Grand View Research., 2023).

**Figure 3. Digital Pathways in Education and Skills Development: A Conceptual Framework**



Source: Author's analysis.

Note: The four layers are aligned with the core principles outlined in the [World Bank EdTech Approach paper](#): Adaptable across school and post-secondary education, NEETs, out-of-school youth and FCV contexts; Requires engagement across local, regional, national levels; Relevant across modalities, for example, tech-enabled face-to-face, blended/hybrid and fully remote modalities; Education ICT and Data Layer includes hardware, software, networking, digital content, information systems, data analytics, and related human capabilities.

The digital pathways of the education system will evolve by traversing all the four layers along both the depth and scale dimensions. Each layer can exert influence other layers both below and above it, and all layers continually and dynamically interrelate. Some layers may be stronger and more established than others or may exert greater influence on decision-making. Hence, care must be taken to ensure that the learning core is always central to all endeavors and strategies and that the chosen digital pathways are a good fit for the country's unique contextual dynamics and processes. The Implementation Layer is highly susceptible to fragmentation and is relatedly susceptible to the formidable digital risks discussed in [Chapter 3](#) given the wide array of EdTech products and services that exist. Hence, it is important to consider ways to ensure a minimum level of digital competence across the population in proportion to their level of digital exposure.

The following subsections will discuss each of the layers and provide examples of how digital technologies can be integrated to enable education transformation.

## 2.2 Deepening Digital Transitions in Education: Shifting to a Systemic Approach

This section discusses the depth of digital transitions, as illustrated in [Figure 3](#), for each of the four layers. The topmost layer (Section 2.2.1) refers to the need for countries' strategic leadership to be collaborative and results oriented. This layer would need to be integrated into the cross-sectoral, whole-of-government ecosystem and the country's critical digital public infrastructure (Section 2.2.2) while interconnecting with the architecture and ICT and data systems of the education system (Section 2.2.3). The user/implementing unit layer (Section 2.2.4) can be disconnected from the rest of the education system unless it is embedded within the education system's architecture and within the country's digital public infrastructure so that they exist and function efficiently together. When the implementation layer can fit into a coherent whole with the layers above, it will help to produce measurable outcomes.



Figure 4. Unpacking the Strategic Layer



## 2.2.1 Education Leadership and Governance (Strategic Layer)

**The principle governing this layer is: ask why (Figure 4).** Policymakers need to understand their educational challenges and determine what educational changes they wish to achieve. They should then enquire whether, to what extent, and in what ways technology can support achieving that educational change and, on that basis, develop a digital pathway that will help to achieve that vision.

**Leadership with a realistic approach to technology, a demonstrated political will, a durable vision for education, and strong partnership coalitions is critical for going digital in education.** See [Box 1](#). A country's socio-economic context, its developmental goals as outlined in its national plans and vision, and its ambition and durable commitment to build its human capital are paramount for setting achievable goals for benefiting from technological advances. Policymakers and IFIs increasingly recognize the need to take proactive measures to govern and administer the use of technology in education while at the same time creating an enabling innovation ecosystem.

**There have been recent urgent global calls for countries to develop digital strategies and action plans to transform education at scale<sup>49</sup>.** UNICEF's 2022 Pulse Check

on Digital Learning highlighted the importance of these efforts, noting that countries with a strategy and plan were more resilient in their use of digital learning during the pandemic.<sup>50</sup> Countries are increasingly recognizing that their education strategies need to evolve in a changing digital landscape while being grounded in their own contextual realities. These strategies must be cross-cutting as they traverse and penetrate all parts of the education system as well as overlap with other sectors (for example, health and employment). Digital strategies must enable the achievement of the end educational goals rather than being the end goal in and of itself. Finally, implementing digital strategies often requires both significant investments and adaptive management as digital solutions require more skilled support and maintenance to ensure that systems are functioning and relevant.<sup>51</sup>

**In terms of data regulation, most countries and regions are taking some measures, but this can be expected to continue to be challenging, especially regarding cross-border data sharing.** Data governance is becoming more complex due to increased data flows across organizations, sectors, and borders, necessitating multinational solutions. Although the components of data governance can be integrated into a comprehensive digital transformation strategy, fragmented legacy systems often impede the implementation of such strategies. The EU has played

### Box 1. The Case for Techno-realism<sup>xx</sup>: A Long History

Techno-realism demands that we think critically about the role that tools and interfaces play in human evolution and everyday life, anticipate the mixed blessings of today's emerging technologies, and recognize the need to be forever on guard for unforeseen consequences that must be addressed by the thoughtful design and appropriate use of digital tools.<sup>52</sup> It also requires us to consider the social and political implications of technologies so that we might all have more control over the shape of our future. The heart of the techno-realist approach involves a continuous critical examination of how technologies—whether cutting-edge or mundane—might help or hinder us in the struggle to improve the quality of our personal lives, our communities, and our economic, social, and political structures.

Source: Shapiro et al (1998).

<sup>xx</sup> Conceptualized in the original Overview and Statement of Principles, introduced on March 12, 1998, it was a collaboration of 12 technology writers—David Bannah, Brooke Shelby Biggs, Paulina Borsook, Marisa Bowe, Simson Garfinkel, Steven Johnson, Douglas Rushkoff, Andrew Shapiro, David Shenk, Steve Silberman, Mark Stahlman, and Stefanie Syman.

a leading role in taking several regulatory policies and actions to ensure that countries design data governance policies and enforce compliance. One key pillar of the [European strategy for data](#), the [Data Governance Act](#) seeks to increase trust in data sharing, strengthen mechanisms to increase data availability, and overcome technical obstacles to the reuse of data. The EU Data Governance Act aims to support the setup and development of common European data spaces in strategic domains involving private and public players in sectors such as health, environment, energy, agriculture, mobility, finance, manufacturing, public administration, and skills. Similarly, the [Canadian 2023–2026 Data Strategy for the Federal Public Service](#) outlines a comprehensive vision, strategic actions, and real-world case studies to enhance the use and value of data Canadians. It aims to align government-wide priorities, shape digital initiatives, and foster coordinated efforts among federal organizations and senior leaders, including chief data officers, to implement data policies and programs effectively.

**Digital transformation is a complex challenge for the public sector that requires thoughtful coordination, advanced digital and change management skills, and the ability to legislate on complex regulatory frameworks pertaining to data and technology, including the rapidly evolving AI landscape.** In the face of such complexity, committed leadership, sustained funding, and strategic foresight are vital to mobilize effective digital initiatives.<sup>53</sup> Adopting an intersectoral approach is critical for government organizations, as it promotes collaboration among professionals from diverse domains such as finance, education, social assistance, and health care in addition to technology specialists. These elements enable governments to deploy state-of-the-art infrastructure, exploit data insights, and use cutting-edge technologies such as AI and 5G<sup>54</sup> to increase the effectiveness of social service delivery while also increasing inclusion and responsiveness to the needs of the people and the planet.

**As governments grapple with intricate and rapid technological advances, skills development in the public sector**

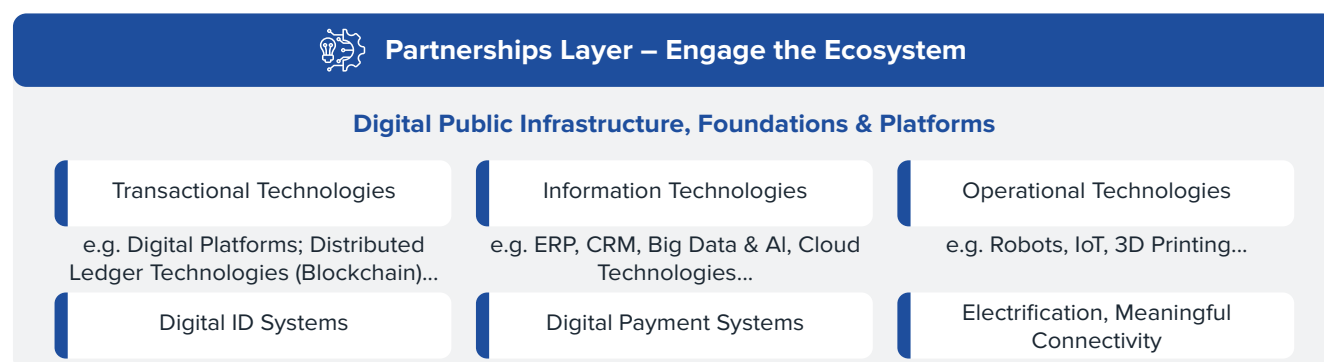
**becomes pivotal to digital transformation endeavors.** Proactive measures are necessary to enhance the capacity of public officials and proactively anticipate emerging digital needs.<sup>55</sup> For example, with increasing digitalization and related datafication, it is imperative to develop the capacity of public officials to deal with the size and complexity of the data for which they are responsible as well as the capacity to manage related risks<sup>56</sup> as data management increasingly shifts towards nongovernmental actors, particularly EdTech vendors. This has traditionally been the remit of specific departments and ministries, but evolving business and citizen demands require public sector staff to acquire an innovative, versatile, and customer-focused mindset.

## 2.2.2 Digital Public Infrastructure, Foundations, and Platforms (Partnerships Layer)

**The principle governing this layer is: engage the ecosystem (Figure 5).** Education systems should take a whole-of-government and multi-stakeholder approach to identify and incorporate innovative and effective ideas to support students, teachers, school leaders and education administrators. Ministries of Education should be proactive in finding ways to identify, incentivize, integrate, and sustain the creators in their country.

**By establishing close coordination and links between the education sector's specific ICT systems and whole-of-government digital foundations, platforms, and infrastructure, education policymakers will be empowered to make better and more data-informed decisions.** The systemic transformation of public education would be deeper and more scalable when the sector is connected with whole-of-government digital infrastructure and platforms. Some countries have further developed their education system architecture to interoperate and integrate relevant information systems for targeted and holistic service delivery (see Moldova's single window procurement systems and secure vendor management systems, Estonia's X-Road, and India's National Digital Education Architecture or NDEAR). Similarly, SOL (short for

**Figure 5. Unpacking the Partnerships Layer**



Online Bidding Solution or *Solução Online de Licitação*) is a Brazilian digital solution designed for community-level procurements for community-driven development projects. In its successful pilot in Brazil, SOL demonstrated its potential to enhance efficiency, transparency, and governance in procurement processes. The app streamlines connections between community associations and suppliers, automating the entire procurement process and increasing audit capacity by providing secure data storage.<sup>57</sup>

**While shared digital public infrastructure and governance structures tend to increase long-run efficiency and reduce fragmentation, they need engagement from and close coordination among a broader ecosystem of partners.** Some clear areas of synergy can be found in the human development sectors, especially areas that could benefit from economies of scale. This is particularly relevant in underpinning platforms, infrastructure, and other foundational elements such as unique IDs, data system architecture (education information systems, health information systems, and social protection information systems), remote services (telemedicine and remote tutoring), and integrated community-level delivery of essential services. Private sector innovation and engagement is critical for enabling greater uptake and use of shared digital public infrastructure, for example, through global, regional, and local innovation communities and hubs. There is a need to consider the role played by transactional, informational, and operational technologies in producing efficiency gains and reducing costs and the frontier developments (see [Box 2](#)).<sup>58</sup>

**There are opportunities to harmonize data systems and infrastructure related to the human development sectors.** For example, the architecture of and approaches to management information systems in health, social protec-

tion, and education can move from legacy systems to more fully interoperable and integrated systems, including such innovations as unique IDs. Aadhaar, India's unique identification system, is the cornerstone of the country's data infrastructure, providing a centralized means of uniquely identifying residents. This system plays a pivotal role in various data systems, offering a reliable foundation for streamlined services, efficient governance, and enhanced data management across diverse sectors. Cross-sectoral human development interventions can be particularly relevant for out-of-school youths, those not in education, employment, or training (NEET), and those in the school-to-work transition if the interventions focus on the development of specific skills. Digital payments across all sectors, including in conditional cash transfer programs, is another crucial way to deepen the transition systemically. Digital payments enable transparent and efficient incentive design, increase transparency and resilience, and reduce switching costs, which is especially important for protecting the most vulnerable in times of crisis. See [Box 3](#) for Estonia's experience.<sup>59</sup>

**To reach all learners, empower teachers, and facilitate data-driven decisions in the education sector, a whole-of-government approach and strategy that engages a broader ecosystem of actors in a country is essential.** Education systems, equipped with their resources, skills, and interdependencies, cannot bear the sole responsibility for steering a country's digital transition. The complexity of this transformative journey necessitates a broader national context encompassing various sectors and stakeholders. Effective leadership is pivotal in coordinating the efforts of governmental bodies, educational institutions, and industry partners. To guide this intricate process, an evidence-informed roadmap is indispensable.

### Box 2. Classification of Technology based on the Nature of Cost Savings

**New digital technologies vary in their underlying source of efficiency gains, one of which is cost savings.** Based on the nature of their cost savings, these technologies can be organized into three types:

- **Transactional technologies digitize business models.** Examples include digital e-commerce platforms and blockchain. The fundamental driver is the falling cost of matching demand and supply. The main effect is to reduce information asymmetries and facilitate market transactions that otherwise might not happen.
- **Informational technologies exploit the exponential growth of data.** Examples include business management software, cloud computing, big data analytics, and machine learning. The fundamental driver is the falling cost of computing. The main effect is to lower coordination costs.
- **Operational technologies combine data with automation.** Examples include “smart” robots, 3D printing, and the Internet of Things (IoT). The fundamental driver is the falling cost of automating routine functions with “smart” machines. The main effect is to reduce production costs including labor, materials, and, in many cases, energy.

Source: Hallward-Driemeier et al (2020).



### Box 3. Enterprise Architecture in Estonia

**Estonia uses an interoperability framework that plays a role similar to an enterprise architecture.** The Estonian IT Interoperability Framework is a set of standards and guidelines to ensure communication between the information systems of central and local government agencies. The IT Interoperability Framework employs three perspectives: organizational, technical, and semantic interoperability. This enables decentralized public and private databases to be interoperable at the national level. For example, when the birth of a child is registered on the Estonian State Portal “eesti.ee,” the child is automatically registered for benefits and enrolled in school. This is possible only because of the interoperability of the Population Registry, the IT system of the Education Department, and the IT system of the Social Insurance Board. This Interoperability Framework is not written into law. However, its obligatory nature is regulated by the legal agreements among government agencies, the private sector, third sector organizations, and private citizens who can submit proposals to access data.

**The aim of the IT Interoperability Framework is to ensure that state information systems are citizen-focused and service-based.** Estonia applies open standards and open-source-based solutions in information systems to ensure their interoperability. Over 150 public sector institutions are connected to X-Road, which provides unified and secure data exchange between the public and private sector bodies and is used daily by more than 1,000 organizations. It is calculated to save more than 820 years of working time for the state and citizens annually. However, these savings are the result of only 5 percent of queries done via the X-Road, as they do not take into account all the savings that occur because of the automatic machine-to-machine data exchange, which amounts to 95 percent of the queries. The Estonian government estimates that its digital infrastructure has led to annual savings of about 2 percent of GDP.

Source: e-Estonia (n.d.) Liimatainen et al. (2011), Mayakul et al. (2019), and Ministry of Economic Affairs and Communications (2011).

This roadmap must be concise yet comprehensive, outlining strategic goals and milestones in manageable stages while being flexible enough to adapt to evolving technological landscapes and societal needs. See for example the [National AI Policy for Rwanda](#) that clearly identifies several lead institutional actors across the government. A methodical, purposeful, and staged approach helps to manage risks and allows for course corrections and continuous improvement to enable the equitable distribution of benefits. However, if the whole-of-government strategy does not consider the local country context, its readiness for the implementation of digital technologies, and the physical infrastructure needed to do so, it will not bear fruit.

**The electrification of learning environments, both at home and at school, is a nonnegotiable prerequisite for pursuing digital transitions in education.** It is foundational for providing safe and conducive learning environments in all seasons, even during extreme weather events, while enabling the use of devices and connectivity and realizing the full potential of digital and ICT implementation. Furthermore, it extends study time by ensuring the consistent availability of lighting and heating in the many schools that operate in multiple shifts or offer flexible remediation options. Adequate lighting is crucial for teachers’ activities such as lesson preparation and planning. A study that examined the broader relationship between electricity consumption and education across 210 countries revealed a strong correlation (above 66 percent) between electricity consumption per capita and higher scores on the education index.<sup>60</sup> Some tangible examples

of the educational benefits of electrification initiatives include reduced truancy rates in Argentina after electric lights were installed in schools and significantly increased completion rates for primary and secondary schools in Sudan and Tanzania because of the availability of solar energy.<sup>61</sup> Without adequate energy supply, deep digital divides will continue to exclude poor rural communities.

**The expansion of broadband networks that offer meaningful connectivity is imperative for fostering educational equity.**<sup>62</sup> A dependable, affordable, and good-quality broadband connection is indispensable for students who need to access various online educational resources, including interactive learning platforms, virtual tutoring, and e-books. These resources enrich their learning experiences and complement traditional classroom teaching, empowering students to delve into subjects beyond their textbooks. Particularly during crises, as exemplified by the recent COVID-19 pandemic, the necessity of remote learning becomes apparent. Expanding broadband networks facilitates students’ engagement in virtual classrooms, online lectures, and collaboration with their peers and educators through videoconferencing platforms. This ensures the uninterrupted continuity of education irrespective of any physical barriers. In the contemporary digital era, proficiency in technology and digital literacy is imperative for preparing students for the future workforce. The expansion of broadband networks serves as a catalyst for fostering these skills, providing students with the essential tools for online research, communication, critical thinking, and problem-solving.

**National Cloud Computing and broadband infrastructure are critical digital infrastructure that should be shared among public agencies, including the public education sector.** This critical digital infrastructure should be shared among public agencies, mirroring the cost-saving aggregated demand approach of higher education research networks. A cost-effective way of minimizing expenditures for government cloud and internet infrastructure is to take a strategic approach instead of a fragmented one. The government can consolidate procurement and standardize service delivery by distributing the recurring expenses related to cloud and connectivity services among various ministries. Within the domain of public services, Canada's My Canada Sign-On optimizes efficiency and convenience by consolidating access to various portals (for example, healthcare, grants, driver's licenses, and taxation) under a unified 'single sign-on' login system. Additionally, Ministries of ICT/digital and Ministries of Education are pivotal in driving digital transformation and educational initiatives. The focus on alignment between government bodies highlights the importance of cohesive strategies, while joint decision-making on budget allocations can be used to reduce costs and optimize resources.

**Integrating more complex digital data systems into education requires robust infrastructure support and increased capacity of public institutions and public sector personnel at all levels.**<sup>63</sup> Real-time data systems can range across the spectrum of digital technologies—from those that depend on face-to-face surveys and observations to sensor-based automated computational systems that rely on web- or application-based tools for computers, tablets, and phones (with smart or basic features) for collecting, sharing, managing, and reporting data.<sup>64</sup> For example, the Digital Credentials Consortium (DCC) is an international network of 12 universities that are working to develop shared digital infrastructure for issuing digital credentials, conducting user research within higher education institutions, and producing open-source technol-

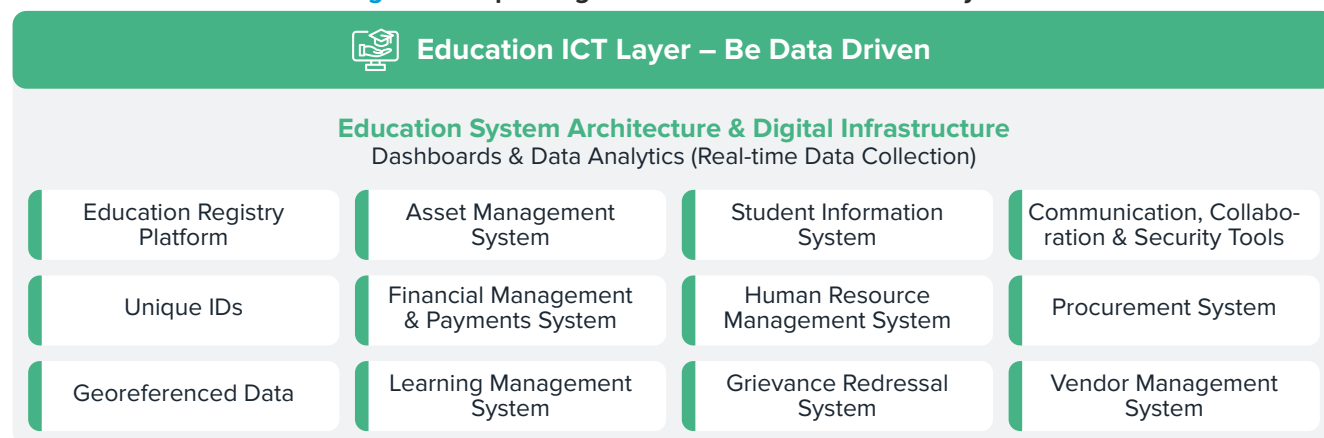
ogies that enable the issue, storage, and verification of digital credentials.<sup>65</sup> Another example of university-led shared infrastructure is the National Research and Education Networks (NRENs) in which universities pool their connectivity needs and engage in collective bargaining to reduce costs. NERNs also share computer infrastructure and virtual labs and conduct joint research.

### 2.2.3 Digitally Enabled Education System Architecture (Education ICT and Data Layer)

**The principle governing this layer is: be data driven (Figure 6).** Transparent standards and interoperable data architecture are key to making evidence-based decisions and building a culture of learning and experimentation. Countries should have flexible, scalable data systems that avoid data silos and vendor lock-in. A culture of gathering rigorous data about the impacts of technology use is an emerging priority.

**Education leaders must design, develop, agree on, and promote the architecture and shared digital public infrastructure of the education system to ensure that it has a system-wide impact.** The ICT architecture of the education sector includes hardware equipment and devices, software and networking applications, standards and protocols, tech stacks, registers, microservices, plug-ins, cloud services, data storage and protection procedures, information systems etc. Choosing appropriate technology and devices has a positive effect on learning outcomes.<sup>66</sup> Education policymakers, like those in all industries, are recognizing that technology is not a luxury but is as fundamental as other resources (schools, electricity, and learning materials) to promote learning. Devices should be selected based on their educational use, such as collecting data, teacher professional development (TPD), teaching reading and literacy, or use in remote or hybrid learning. The education system's ICT architecture should

**Figure 6. Unpacking the Education ICT and Data Layer**



#### Box 4. Data Storage and Management in Education in Estonia

**The Estonian Education Information System (EHIS) is a state-run, web-based database that stores live data on education and is accessible to different public groups to a varied extent.** All schools and institutions following a curriculum are obligated to enter up-to-date data into the EHIS by law, including kindergarten, primary schools, secondary schools, vocational training courses, universities, and adult education. The EHIS performs automatic logical consistency checks to ensure that the uploaded data are reliable and accurate. Each school has online access to the EHIS through the user interface and can enter data in three ways. *First*, schools' digital tools and digital management software are connected to the EHIS so the data can be automatically transferred from the school management system to the EHIS without the need for any additional actions. *Second*, schools can generate Excel sheets and upload XML files to the EHIS. *Third*, the school data can be manually entered into the EHIS user interface. The E-Service Department of the Ministry of Education and Research is responsible for solving any data entry issues that schools might encounter. Schools can monitor students' and teachers' data through the EHIS user interface. In addition, an online platform in the EHIS named Educational Eye makes school statistical data available to the public. In addition, about 50 specific service providers can access a broader range of contract-specified data in the EHIS under strict legal conditions when they need to certify students' identities to provide them with a public service. Furthermore, over 20 other state-run information systems are connected to the EHIS for data exchange with other state-run information systems. Various digital online tools supporting education delivery and progression are connected to the EHIS via X-Road (see [Box 3](#)) to complement the data in the EHIS.

Source: Maio et al (2020).

combine technology, data, and, most crucially, the human capabilities needed to leverage the benefits of these investments at scale. These investments may include a variety of hardware devices, equipment, and software applications that are linked to information systems/exchanges and have real-time analytics capabilities. See [Box 4](#) for Estonian example.<sup>67</sup>

**The education system architecture supported by digital infrastructure enables learners, teachers, parents, and administrators to be data driven, which improves the delivery of education services.** Countries such as Estonia, Uruguay, and the Republic of Korea have actively invested and built these capabilities throughout their education systems at the national, regional, and local levels. As a result, these systems are more resilient, adaptive, and responsive to the needs of students, teachers, and administrators in normal times and in crises. Critically, the architecture of the sector needs to be aligned with the government's structure (for example, centralized versus decentralized) to ensure that all government officers, from local government authorities to national departments, can use and benefit from it. This includes infrastructure that allows for the easy storage and charging of devices in schools (such as charging cards), software and network protocols for interactive and secure intranet capabilities, and user-specific dashboards to extract, collate, analyze, and potentially forecast data in real time when systems are interoperable across education information system modules.

**The digitalization of real-time administrative and student assessment data makes it possible for educators, policymakers and parents to respond dynamically to**

**student needs and to improve student learning.** Learning management systems that use real-time data collection and analytic tools to enhance classroom-level decision-making include blended, in-person, and offline modalities such as those in Kosovo ([Shkollat.org](#)), Gujarat, India ([Command and Control Center](#)), and the Guanajuato district in Mexico ([RIMA](#)) (see [Box 5](#)<sup>68</sup>). Real-time data also enables closed-loop experimentation for the iterative impact evaluation of interventions.<sup>69</sup> It can improve the accuracy of predictions and automate repetitive tasks for teachers and school administrators. This data can be used to create feature-rich lesson plans using feedback from teachers at local and regional levels. Data-driven lesson plans can help the teacher plan and provide differentiated instruction, guiding students as they explore their curated learning journeys. Used well, these data can also help students to complete their homework, receive feedback in real time, and receive clarifications of any misconceptions using an inquiry-based Socratic process while teachers still receive an analysis of the student's learning data.

**Digital technologies offer the potential for efficient collection and analysis of real-time data, though the chosen tool needs to be appropriate to the context and purpose.** Paper-based data collection systems are slow, administratively burdensome, and prone to human error. Factors to consider when choosing a digital tool include its hardware and software requirements, supported modalities, connectivity, offline capabilities, interoperability, backward compatibility, adaptive capabilities, real-time/dynamic capabilities, costs, cost-effectiveness, licensing, functionalities, decision-making features, reliability,

### Box 5. Data Collection, Analysis, and Dissemination for the Improvement of Learning (RIMA) (Guanajuato District in Mexico)

The Secretary of Education of the State of Guanajuato in Mexico has designed and implemented a diagnostic tool called **Information Collection for the Improvement of Learning (RIMA)** to assess student learning. This instrument uses a census-based measurement approach to evaluate students' performance in mathematics and Spanish, socioemotional competencies, and school environment. Specifically, it targets primary students in grades 4 to 6 and secondary students in grades 1 to 3 in both public and private schools. RIMA is based on the formative evaluation approach, which provides reliable information to inform the continuous development of the teaching-learning process, of teacher training, and of family involvement in education. The state coordinates and implements the entire RIMA process, supervising the evaluation process and disseminating customized evaluation results based on user-type, be it teachers, students, parents or schools.

**Different stakeholders can access the RIMA analysis results and recommendations online, giving them the information needed to identify good practices and improve the education system.** The analysis results can be viewed on the indicators portal of the website of the Guanajuato State Secretary of Education by parents or guardians by typing in the student's Unique Population Registry Code (CURP) in the RIMA portal [here](#). Relevant [supervisory](#), [managerial](#), and [teaching personnel](#) can also view the results using their institutional credentials. The results are presented visually and show the percentage of correct and incorrect answers, which can be filtered by subject, school, grade, shift, and group. The site also gives recommendations to reinforce the learning and guidelines for parents or guardians. The result report can be downloaded in MS Excel. The RIMA data in 2021 were used to assess the learning losses of over 600,000 students in the State of Guanajuato during the school closures due to the pandemic and revealed that students achieved only 40 percent of the curriculum goals on average, with the most significant learning losses having been experienced by indigenous populations, girls, and students in the afternoon shifts at public schools and in rural areas.

Source: Secretary of Education of Guanajuato (2021a and 2021b).

target environment, target population, user-friendliness, design accessibility, digital literacy requirements, human resource requirements, language offerings, geographic compatibility, subject/sector alignment, and data protection and privacy provisions.<sup>70</sup> EdDataTools offers a mapping of technologies throughout the data lifecycle in the education-in-emergency (EiE) sector, which has been compiled through research and crowdsourcing. While not comprehensive, this mapping can complement other sources when exploring what tools are available. It can serve as a resource to assist in determining which technologies are most effective for the specific context in question.

**Real-time data can include data for tracking ongoing school activities and data for observing the progress of instructors and learners, which together can be used to inform adaptations to educational inputs, activities, and outputs.** Administrators (such as school or government leaders or program facilitators) can use performance information to adaptively manage the resources of their institutions and tailor education programs to the needs of students and instructors. Similarly, educators can use student data to ensure that they are teaching at the right level and to customize their instruction based on individuals' learning patterns and needs. The Ministry of Education in Singapore has implemented the Student Learning Space platform, which provides teachers with real-time data on

the engagement and performance of their students. The platform enables them to provide timely interventions and support students who might be falling behind, demonstrating how real-time data management can enhance learning outcomes.<sup>71</sup> Students, families, and communities can use real-time data to track their progress and use this information to advocate for their needs.<sup>72</sup>

**Digital analytical platforms are being used to enable and support outcomes-based financing and adaptive management.** A rise in interest in outcomes- and results-based financing (including social and development impact bonds and outcomes funds) among policymakers, funders, and practitioners has led to increased use of real-time data and adaptive management. For effective results-based financing to work, real-time performance data from institutions can provide feedback on necessary and timely improvements required to qualify for the next financing condition.<sup>73</sup> In Argentina, for instance, the national Ministry of Education used a digital platform to provide real-time tracking of schools and measurement of their educational outcomes to facilitate the implementation of an outcomes-based financing model.<sup>74</sup> Moreover, a variety of digital payment systems exist that enable direct account transfers, mobile money transfers, e-vouchers, and digital wallets to pay salaries and make other payments quickly and to distribute conditional cash transfers to schools, teachers, and families.



Digital analytical platforms using real time data and adaptive management have the potential to revolutionize education systems by enabling schools and teachers to continuously adjust their strategies based on data-driven insights.<sup>75</sup> For instance, an adaptive management system included in the Educate Girls Development Impact Bond initiative in India allowed for timely course corrections and has had positive impacts on student outcomes.<sup>76</sup> In Kenya, the [Tusome Early Grade Reading Activity](#), supported by United States Agency for International Development (USAID), used digital tablets to collect, analyze, and monitor data on students' reading performance to inform teachers of the need for any necessary adjustments to their teaching strategies to improve learning outcomes.<sup>77</sup> Establishing and refining adaptive management systems is increasingly essential for service providers engaged in outcomes-based financing. This requires specialized skills for digitally enabled real time data management capacity.<sup>78</sup> This approach can be valuable at all stages of a program's lifecycle, from design to implementation, and it can inform immediate operational adaptations at the front line of educational instruction as well as strategic adaptations at the systemic level.<sup>79</sup> Education data plays a crucial role in enabling decision-making by government administrators at various levels, aiding in policy design, strategic planning, resource allocation, and personnel decisions, including the employment and training of administrators, teachers, and staff.<sup>80</sup>

**Information systems and the intelligence that they contain must be carefully governed and safeguarded to ensure the depth of the digital transition.** A coherent and effective information system provides the right insights at the right time, with the right frequency to the right people in a clear, understandable and actionable manner. For this, it is essential to have a well-thought-through education enterprise architecture and implementation plan. While various tools have different functionalities and features, the core system architecture must be based on 'core' objectives for the education and skills development sector. It must strike a balance between ensuring interoperability between systems and tools and protecting users' data.

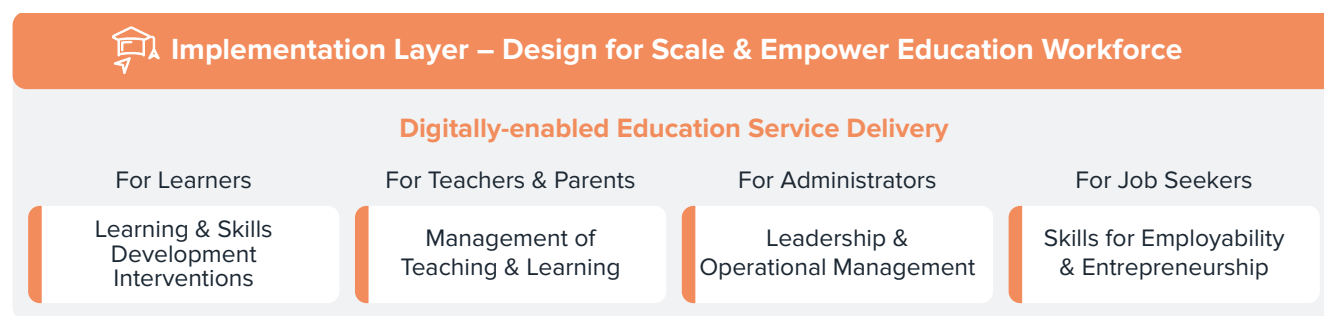
## 2.2.4 Digitally Enabled Service Delivery (Implementation Layer)

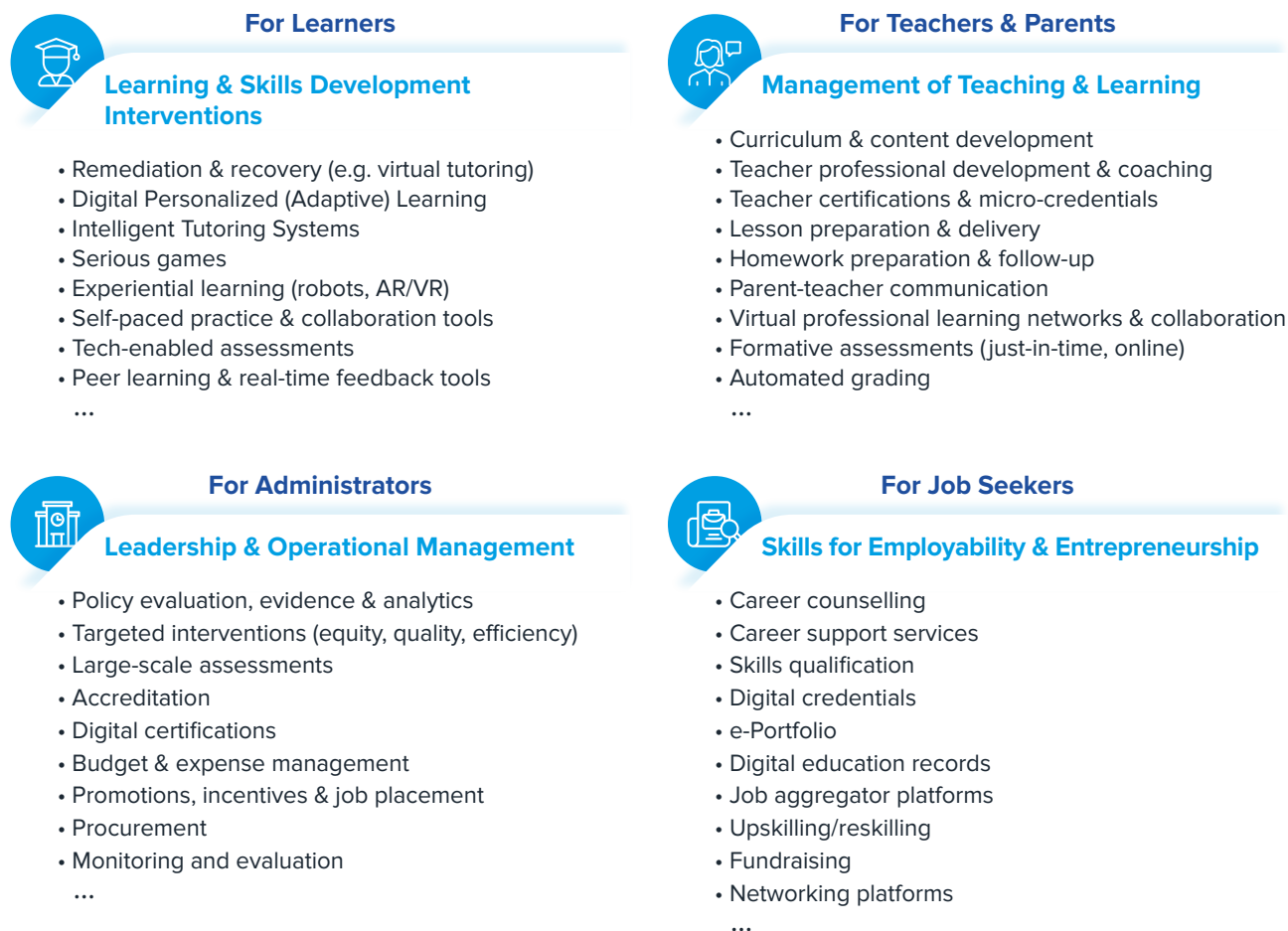
The principles governing this layer are **design for scale and empower teachers** ([Figure 7](#)). Starting the design process by considering how technology can be used to benefit everyone, leveraging 'anytime, anywhere' affordances of digital solutions can ensure that such initiatives are both equitable and adaptable to specific contexts and thereby sustainable at scale. Technology should enhance teachers' engagement with their students by giving them access to content, data, and networks that allow them to provide personalized student learning. Digital solutions cannot fully replace teachers; they can best be used to augment teaching and learning. Evidence from around the world shows that, over time, the role of teachers becomes more central, not less, for the effective use of technology.

**Digitalization efforts have the potential to significantly improve the delivery of services at various levels, making a tangible impact on learners, teachers, caregivers, and administrative bodies.** For learners, digital applications offer versatile learning and skills development opportunities through various channels and modes. Teachers, caregivers, and communities can use digital tools to help them to efficiently manage the teaching and learning processes, enhance their pedagogy, and tailor their approaches to train and coach adult learners. Administrators and deans can use digital technologies to improve their administrative management. This section highlights: (i) how technology can support each of these user groups through the adaptation and integration of low-tech and high-tech tools and (ii) how digitally enabled service delivery during implementation can better integrate with the previous layers ([Figure 3](#)) to deepen the transition and have a more sustainable impact. A broad overview of technologies, products, programs, and emerging trends is presented in this section, while evidence of their effectiveness is presented in [Chapter 3](#).

**A wide array of hardware and software options contribute to the multifaceted nature of the digital world**

**Figure 7. Types of Digitally Enabled Education Service Delivery**



**Figure 8. Array of Applications in Digitally Enabled Service Delivery**

Source: Authors' illustration.

(**Figure 8**). Hardware includes radio, TV, e-books, tablets, smartphones, interactive whiteboards, and computers, while algorithms and software include QR code scanning, optical character recognition (OCR), word processors, videoconferencing tools, anti-plagiarism software, content/learning management systems, chatbots, instant messaging, and AI. Moreover, as technology advances, hardware and software are increasingly enmeshed such as in the case of virtual reality/augmented reality (VR/AR) and simulation games. These tools can be deployed remotely, virtually, in face-to-face settings, or in blended modes, offering practical solutions to enhance educational processes and outcomes in real-world scenarios.

### ***Learning and Skills Development Interventions for Learners***

The term “learners” encompasses individuals of all ages engaged in various kinds of learning, including formal education, professional or vocational training, and non-formal education. Technology plays a versatile role in education, facilitating engagement through remote, virtual, face-to-face, blended/hybrid, or synchronous or asyn-

chronous modes. EdTech serves multiple purposes, acting as a primary, complementary, additional, or supplemental resource in various learning environments, supporting self-led learning, mentor connections, and teacher/parent interactions.

**Regarding self-led learning, technology enables student doubt resolution, self-paced learning, and gamified or immersive approaches.** Doubt resolution tools such as Doubtnut and Wolfram Alpha leverage OCR and AI technologies, while pre-set self-learning content can be unsequenced (for example, on YouTube) or sequenced (for example, via online courses). Massive Open Online Course (MOOC) platforms provide wide-ranging accessibility by combining interactive self-learning and peer-to-peer learning, including game-based approaches such as Eneza Education and gamified learning paths such as Kitkit School and Read Along. Using gamified augmented and virtual reality applications is becoming increasingly prevalent in corporate training, higher education, vocational programs, and academic institutions. This trend increases the effectiveness, cost-efficiency, adaptability, consistency, and security of [apprenticeship opportunities](#).

**Despite a myriad of applications, most tools operate in silos, which hinders data-informed service delivery.** Aggregated data often benefits product owners rather than public education providers and users. Integrating synchronization features, as in [Kolibri](#), is crucial for leveraging aggregated data for learning analytics. While learning platforms at various levels provide feedback to teachers (such as [Tangerine: Teach](#), which also helps teachers to interpret the data), there is a missed opportunity for greater regional and national aggregation and use of feedback-based learning analytics and formative assessment data. Developing interoperable products and programs that adhere to the architecture and protocols of a nation's education system is crucial. This is necessary to enable the collection and analysis of real-time data while maintaining and safeguarding user privacy.

### ***Management of Teaching and Learning for Teachers and Parents***

**Digitally enabled education interventions can empower teachers and parents.** These interventions include new and enhanced forms of lesson and content creation, teaching and lesson delivery aids, professional development, coaching, professional learning networks (PLNs), accreditation, formative assessment, and grading. There is a huge variety of digital applications to support the planning, delivery, and management of teaching and learning, focused on strengthening the interactions between teachers and students, among teachers, between parents and teachers, and between teachers and the education system ([see Box 6](#)).

**In lesson preparation, technologies are reducing the need for teachers to create engaging and tailored lesson plans from scratch.** EdTech Hub's [guidelines for effective lesson planning tools](#) recommend tools that encourage effective pedagogical practices (for example, student interaction), align with national curricula, provide subject-specific examples and pedagogies, encourage collaboration and reflection among teachers, are relevant to the teachers' culture, language, and context, and are adaptable to the teacher's prior knowledge and expertise levels. Notable products of this sort include LearnZillion with high-quality text-based lesson plans, Diksha and Funda Wande with multimedia, Kolibri with offline open educational resources (OER) and curriculum alignment, Edraak with question banks, Oppia with community-built resources that are adaptable, Teacherly with content that is editable and strengthened through peer feedback, Khanmigo using generative AI and has curriculum alignment functionalities, and Nearpod using AI, visualization, and interactivity.

**Moreover, content development is changing rapidly with the availability of open educational resources (OERs)**

**and open-access AI tools.** In terms of OERs, the African Storybook Project has created a digital library of openly licensed African storybooks that constitute appropriate reading materials for young African children in home languages that reflect local content and have been piloted in several African countries. Open or partially open-access AI tools such as [Dalle](#), [Stable Diffusion](#), [Lexica](#), Chat GPT, Claude, Microsoft [Bing](#), [Meta Llama 2](#), and [Google Bard](#), among many others, are democratizing the creation of educational content by empowering students, teachers, and anyone with interest, access, and know-how to create their own content. Moreover, there are various digital tools aimed at enhancing reading literacy, such as digital storytelling and storyboarding, as well as tools that enhance creative writing.

**Similarly, in lesson delivery and homework design, technologies exist that help teachers to provide increasingly personalized instruction to students, as highlighted earlier in this report.** For instance, the teacher assumes the role of an instructor in the TV-based Sesame Street Workshop, while Matific and Mystcraft employ games and augmented and virtual reality simulations to facilitate learning. Similarly, there are homework preparation tools that automate corrections and feedback,<sup>81</sup> assist instructors in generating, assigning, and ensuring that students comply with and complete assignments, and save teachers' time and effort. Each of these tools fundamentally alters the instructor's function in the educational process and requires them to acquire fresh proficiencies. Similarly, there are popular 24/7 homework help tools such as Chegg<sup>xxi</sup> for high school and college students and for those going through the school-to-work transition.

**For teachers, digital solutions offer a variety of professional development and coaching opportunities that would not otherwise be available.** Technology can enable many-to-many connected networks, scalability, adaptation, and audiovisual features, among other affordances to help teachers with their professional development. From the use of apps such as WhatsApp, Skype, and Telegram by teachers and school communities to videoconferencing and real-time audiovisual solutions, TPD is being revolutionized by digital tools that can simulate students giving real-time and post-teaching. Teachers have access to digital content that helps them to improve and achieve mastery over core academic concepts, improve their skills and classroom practices for effective delivery of instruction, and build their capacity for using digital tools in teaching. See [Box 7](#) on a UK experience.<sup>82</sup>

**The anytime, anywhere availability of a wide range of professional learning networks (PLNs) has the potential to support teachers' professional development.** Numerous virtual and global professional learning networks

xxi Chegg generated the most revenue of any educational app in 2022 at US\$766 million, out of 455,000 'educational' apps in Google Play and Apple App Store.

### Box 6. Changing Role of Teachers: From Provider to Facilitator to Cultivator and Coach

It is now widely acknowledged that the role of teachers as the sole providers of knowledge is no longer valid given the widespread democratization of information through public community centers and print and digital media. Yet teachers' roles cannot be merely reduced to facilitators, connectors, and coordinators of knowledge. The teacher's role is to cultivate learning experiences, nurturing the human potential of each learner, strengthening their critical judgement and discernment, enabling collaboration and conviviality, and kindling curiosity and creative thinking. Their pedagogical role remains essential in the learning process and is ever more critical in the digital age, even though they may not be the sole purveyors of knowledge.

Source: Authors.

(VPLNs)<sup>83</sup> cover educators' diverse needs and interests. They are enabling teachers to modify their mindsets and practices through collaborative reflection and by sharing expertise across contexts, for example, [Edmodo](#)<sup>xxii</sup> and [Times Educational Supplement](#)<sup>xxiii</sup>. Virtual one-on-one human coaching for teachers can be provided in real time, although evidence of its long-term sustained impact on teacher effectiveness is mixed.<sup>84</sup> This can be through text messages, voice calls, or video calls. Teachers can also upload their instruction videos to platforms, and coaches then provide them with timestamped comments and suggestions.

**Similarly, albeit slowly, modularized learning offered through micro-credential certification programs is gaining traction in education and training in more advanced economies.** In many EU countries, micro-credentials are becoming more prominent within qualification systems on the basis that they offer students greater flexibility and are more suitable for building sector- or occupation-specific skills (reskilling/upskilling) in response to the changing needs of industry.<sup>85</sup> Their links to formal educational qualification frameworks are growing with the adoption of related regulations in many EU countries such as Estonia, Denmark, and Ireland. Notably, these frameworks

allow educators to earn points by providing evidence of continuous professional development and lifelong learning and prior learning. Accumulating professional credits can make teachers more competitive for certain roles or promotions. For example, in the United States, many districts have a "step and lane" pay scale where teachers can move over a lane (that is, increase their pay) by accumulating credits, including micro-credentials.

**Teachers can use technology to develop just-in-time formative assessments to offer tailored support to learners, while also including collaborative engagement with parents in their children's learning.** Using technology-enabled formative assessments allows teachers to gain comprehensive insights into students' learning, to identify their strengths and any areas for development, and counter any individual or group misconceptions. An illustrative example is ChalkTalk, an AI-enabled tool that enables the teacher to leverage student performance data to provide students with differentiated support through data dashboards. In this context, teachers can assess lexile levels of texts,<sup>xxiv</sup> thereby customizing reading content to better suit individual needs. Additionally, tools are being implemented to empower parents with guidance and activities to support their child's learning and development at home.

### Box 7. Supporting Teachers to Strengthen their Pedagogical and Administrative Practice in the UK

In the UK, skilled teaching staff are vital for determining the quality of digitally enabled education. To strengthen the pedagogical and administrative practice in education using technology, the UK partnered with the Chartered College of Teaching to launch a free online training course available to all teachers and education leaders. This training course strives to improve how technology is used in teaching alongside other training opportunities offered by the ICT industry. The UK has also been supporting the British Educational Suppliers Association's LearnedED program, which brings together teachers and industry to showcase EdTech products and best teaching practices that use technology through eight accredited continuing professional development roadshow events that are free of charge. Teachers and education leaders are invited to observe a range of technologies in action and share practical technology-based teaching practices with each other. The UK also has plans to establish a network of "demonstrator" schools to showcase best teaching practices that use technology with the support of the EdTech Leadership Group. The network will draw on industry expertise and learning from various school leaders. The "demonstrator" schools are expected to offer visiting teachers with peer-to-peer support and training programs.

Source: Hinds (2019).

<sup>xxii</sup> Edmodo is an educational technology platform designed for K-12 schools and teachers to facilitate communication, collaboration, and learning management. It provides tools for educators to create classes, share educational resources, assign tasks, and engage students in interactive learning activities. Edmodo aims to enhance classroom efficiency and connectivity through its online platform.

<sup>xxiii</sup> The Times Educational Supplement (TES) is a UK-based publication and online resource widely recognized for its educational content and resources. Originally a newspaper, TES has evolved into a comprehensive online platform offering articles, teaching resources, lesson plans, and educational jobs. It serves as a valuable resource for teachers, educators, and school administrators worldwide, providing insights, news, and tools to support teaching and learning practices.

<sup>xxiv</sup> While the lexile levels enable tech-based targeting, developing student's reading skills is a complex task that cannot be swiftly codified and hence the role of teacher as a reflexive coach and cultivator is critical. See <https://creativeteachersclassroom.com/2016/06/27/why-its-time-to-leave-lexiles-behind/>



Through proactive communication, teachers and parents can seamlessly integrate each other into the student's learning journey, fostering a cohesive connection between home and school. Just as tools help teachers to provide feedback to learners (for example, Tangerine: Teach), similar tools can also assist coaches in offering constructive feedback to teachers (for example, Tangerine: Coach).

**As with the plethora of products and programs to support learning, those currently created for teachers, coaches, parents, and communities are largely used in a disjointed way, often being implemented in a group of schools by a particular network or donor.** In some cases, sets of schools are implementing multiple (often unaligned) TPD programs, which can overburden teachers, while other schools are implementing no programs. While learning analytics data is useful at the school level, if done nationwide, it can inform education decision-making. Where multiple programs are being implemented to support teachers, they need to be regulated by the government and aligned with the national education plan and the country's protocols, and curricula (such as the national [MEWAKA program in Tanzania](#) or the [National Numeracy Program in Malawi](#)).

### ***Administrative and Operations Management for Education Leaders, Administrators, and Multilevel Education Officers***

**Governments—at the local, regional, and national levels—have an opportunity to use digital technologies to support teaching and learning, pedagogic management, and administrative management functions.** They can do this by implementing national learning management systems for learners and teachers, improving teacher allocation and placement using geospatial analysis, improving teaching and learning through digital personalized instruction, targeting resources and academic recovery programs based on data from the EMIS, and enabling innovative policy design and rigorous impact evaluation using learning analytics.

**To ensure for effective education administrative and operational management, it is crucial to carefully balance centralized and decentralized digital governance policies in accordance with the capacity, context, and digital maturity of the country.** Governments grappling with fiscal constraints may be drawn to decentralization's potential to enhance spending efficiency or to centralization's potential to leverage scale and exert stronger budgetary control. However, the administrative governance of digital investments in education must be well balanced to ensure efficiencies of scale. This might mean establishing a shared nationwide digital infrastructure and centralized data capabilities and monitoring and evaluation

combined with decentralized digital initiatives adapted to local needs and enforcement of policies and standards. A well-balanced approach to digital governance in education will foster accountability among teachers and principals enabling them to make informed decisions that enhance school operations, teaching quality and learning outcomes. In countries with high levels of inequity and decentralized/semi-centralized governance structures where capacity varies widely across its territory, the awareness, adoption, and use of high-quality and cost-effective educational technology tools may vary significantly. This can lead to high fragmentation, compromising safety and hindering the realization of economies of scale in procurement. Conversely, high-capacity contexts with high digital maturity are often characterized by centralized governance of information and quality assurance, decentralized governance in service delivery and perhaps most importantly, by empowered educators who, having been granted a high degree of autonomy, embrace innovation and adaptability and actively participate in formal and informal learning collaboratives.

**Digitally aware, empowered, committed leaders and educators are key.** Enhancing and rewarding digital capacity development and promoting collaboration across the education and broader public sector ecosystem—at all levels—are essential for ensuring, over time, that digital is not the business of only one department or entity but becomes embedded across the ecosystem as the natural state of play. In many LICs and LMICs that have adopted a semi-centralized approach, if technology is strategically deployed, it can enable the link between *centralized* policymaking, standards development, and budgetary controls, and *decentralized* management, which enforces policies and standards, streamlines administrative processes, enhances communication, and facilitates data-driven decision-making at the local level. Embracing governance models that are appropriate for the digital readiness of the education systems (See [Chapter 4.1](#)) can harness the benefits of technological advances while catering to diverse requirements, ultimately contributing to a more responsive and agile system.

**Technology enables decision-makers to access to real-time data at the right time.** This data-driven approach makes the education system more equitable, improves its quality, and increases its efficiency. It enables the use of data visualization and feedback tools, enhances procurement options, and improves feedback mechanisms to support early warning systems and grievance redress. Indeed, digital solutions are becoming increasingly important in educational institutions' day-to-day administrative and operational management. They are using applications that help them with policy evaluation, evidence, and analytics; targeting interventions with a focus on equity, quality, and efficiency; conducting large-scale assessments; accrediting

ing and issuing digital certificates; managing budget and expense management; informing career progression and job placements; financial and resource management; procurement decisions; and monitoring and evaluations to ensure continuous improvements. Digital technologies can support the entire data value chain—from collection, cleaning, analysis, and visualization to use, reuse, and feedback.

**Given the extensive proliferation of digital tools, there is a clear need to improve procurement processes for digital infrastructure and capabilities.** This includes preparing bid documents, evaluating bids, appraising, utilizing, and tracking the performance of the selected product, and monitoring and evaluating the impact of its outcomes. This requires relevant knowledge and independent expertise for auditing, comparing, and measuring the context-

tual effectiveness of different learning, pedagogic, and administrative tools and platforms. Responding to this need, service providers such as EdTech Tulna have started to provide support to enable policymakers to make evidence-informed decisions.<sup>86</sup>

**Early warning systems with vulnerability and risk indicators can be enabled by real-time data.** These systems can use interoperable data systems to assess the vulnerabilities of teachers and administrators during training and capacity-building and to enable integrated case management and referrals, especially for the vulnerable who may face cumulative barriers to accessing education. They can also use predictive analytics to identify and actively support at-risk populations. Similarly, technology can be used in accreditation and certification processes to produce electronic

### Box 8. Applying Early Warning Mechanisms to Reduce Early School Leaving in Romania

**An early warning system developed and implemented in Romania is helping reduce school dropouts and early school leaving.** The early warning system provides a unitary framework for identifying at-risk students based on real-time data collection, guiding the Ministry of Education, inspectorates, and schools to implement prevention, intervention, and compensation measures to mitigate the identified risks. Following the implementation of a pilot, the early warning system mechanism has been scaled up through a national program, the National Program for Reducing School Dropout (PNRAS), funded by the European Commission (EUR 0.5 billion) under the National Recovery and Resilience Plan.

**Along with the development of the early warning system, a web-based data module was embedded in the EMIS-Romanian Education Integrated Information System (SIIR).** The module collects data through observation, evaluation sheets and self-reported screening tools to identify at-risk students and track targeted activities and progress through students' case files, where teachers can access their student's academic progress, attendance, behavior, and other factors that may indicate a risk of dropping out. This module facilitates the timely detection of risks through real-time monitoring, while increasing cost-effectiveness, increasing accessibility for users, and improving communication between different stakeholders.

**A training program has also been developed to equip users of the early warning system with the skills needed to use it.** The training target group consists of teachers, principals, school administrative staff, county inspectors, and Ministry of Education staff. The training program covers: (i) the early warning system in education, including its components, implementation steps, approach, and tools; (ii) the data module functionalities, user roles, types of data collected, analyses, and reports that can be generated; and (iii) comprehensive methodological suggestions for school and classroom-based interventions for students at risk. It offers a range of flexible learning options, allowing participants to tailor their training to their own pace and schedule and access supplementary resources at their convenience. Since its launch, the online training course has been completed by over 40,000 participants, with an additional 8,000 currently enrolled and progressing through the course.

**The self-paced training course, developed as a virtual learning environment (<https://mate.edu.ro/>) and connected with a learning management system, plays a crucial role in effectively scaling up the early warning system in Romania.** The customizable design of the learning management system leads to easy accessibility, seamless enrollment, progress tracking, automated assessment, and feedback processes, with the ability to engage a broad range of participants in a short timeframe. Moreover, the platform gathers relevant data to inform the continuous improvement of the early warning system, such as tracking of learners' progress, enrollment on the website, completion rates, and the number of schools attended by the trainees, while remaining cost-effective and affordable, upholding the quality, consistency, and flexibility of the learning experience.

Source: World Bank in partnership and with funding from the European Commission (EC).

portfolios, enable time-bound digital signatures for validation, and enable the use of blockchain-based smart contracts for tracking funds and for market signaling through verifiable credentials (see [Box 8](#) for Romania example).

**Grievance redress mechanisms (GRMs) have been implemented in numerous countries to improve public services, including education.** These mechanisms for soliciting and redressing citizen complaints have been widely used in domestic and international development initiatives. GRMs are a way to enhance governance as a whole by promoting accountability and transparency in public services with a specific focus on the welfare of marginalized communities. Digital communication channels are increasingly used in GRMs from lodging complaints and queries to the resolution stage. Also, community engagement and information availability on GRM are increasingly enabled by technology through, for example, large-scale push notifications via subscriber applications, large-scale SMS, and other online messenger and email-based systems, which can be particularly useful in areas facing crises or emergencies. Despite these achievements, GRM endeavors frequently encounter constraints, predominantly due to their local or subnational government focus and their limited ability to feedback into high-level policymaking.

## 2.3 Scaling Up Digital Transitions in Education: Shifting towards Stronger Learning-centered Innovation Ecosystems and Partnerships

**The education sector is increasingly considered an enormous but so far underinvested opportunity for digitalization.** The overall valuation of the private (that is, not publicly listed) EdTech startup enterprises from 1990 to 2022 was US\$332 billion (as a benchmark, the equivalent in health was US\$1.7 trillion), most of which came from four economic regions: the US, China, India, and Europe (as of September 2022). Extensive market consolidation since 2020 are making some companies likely future goliaths with extensive market power.<sup>87</sup> Moreover, Open AI's ChatGPT, launched on November 30, 2022, has become the fastest adopted tool in history, garnering over 1 million users within five days of its launch and 1 billion visitors within only three months. By March 2023, it was estimated to have 25 million daily users. This is expected to have significant implications for education systems.

**The digital education economy is a business frontier growing in size and importance.** First, there has been significant growth in the licensing of education hardware and software and the marketing of education content programming globally since the pandemic by all of the major technology companies (such as Acer, Alphabet, Amazon, Apple, Metaverse/

Facebook, Dell, IBM, and Tencent). Amazon Web Services (AWS) now offers cloud computing programs worldwide, while IBM created the Pathways in Technology Early College High Schools (P-TECH) initiatives to close skills gaps while opening career paths to workers who do not have a bachelor's degree. Microsoft, Google, and many others offer free digital skills development courses. The pandemic led some companies to quickly pivot their product offerings to fit demand, such as [Microsoft for Education](#) and Google Classrooms, competing with open-source solutions, such as Moodle, in both developed and emerging markets. Second, major education technology companies, both private and publicly traded, are now offering a wide range of B2B and B2C applications and tools such as enterprise software, networking tools, learning management systems, auto-grading systems, ITS, skills assessments, and virtual training. New venture capital investments in education have grown by 13 percent.<sup>88</sup> Third, the market also includes telecommunications and internet service providers, impact market intelligence companies powered by AI tools such as HolonIQ and International Data Corporation (IDC), and data brokers and intermediaries essential for running the infostructures required for operating the digital ecosystem for education.

**However, there is a vast array of unproven products and a lack of contextualization (such as availability in local or regional languages), indicating that ensuring inclusion and democratization of such products and services will require strong governance capacity and sustained efforts.** The prevailing market trends are focused on grades and credentials and tend to target population segments that are already connected, digitally savvy, and can afford to pay the high costs of technology solutions. They also carry worrying digital risks due to the large-scale collection and exchange of education and personal data, including through cross-border transactions and flows, especially those targeting highly vulnerable groups—such as children and young people—for recommendations and online advertising.<sup>89</sup>

**Interministerial, intersectoral, and public-private collaboration is essential to mobilize financing, strengthen capacity development and high standards of quality, and ensure that policies, legislation, and regulation support innovation ecosystems while securing systemic and equitable impacts at scale.** For example, the proposed EVER<sup>xv</sup> framework is a way to conduct the quality assurance of digitally enabled education products in which key stakeholders such as governments, postsecondary education providers, and employers must make sure that their underlying systems and technologies advance ethical and equitable access to education and lifelong learning.<sup>90,91</sup> Another example of collaboration comes from the Netherlands. In response to the growing need for more STEM graduates and higher-quality training practices, several

<sup>xv</sup> In developing such an evaluation routine, it is important to embrace methodological plurality that recognizes the value of all types of research, without positioning RCT evidence as the best evidence for all EdTech. EVER can be used for EdTech of any type, including those that are designed to promote foundational skills in literacy and math, those that aim to change learners' behavior, as well as those that combine assessment and intervention (Kucirkova et al, 2023).



government ministries and leading companies in the industry are forging closer relationships with public education through public-private partnership (PPP) centers. The PPP centers are established in schools that offer upper-secondary TVET and higher professional education in collaboration with various private sector companies. The PPP centers are supported by state grants and co-financed with private capital with the aim of enhancing the product market and educational innovation through a structural exchange relationship between schools and the labor market. The PPP centers are autonomous to create their own market niche and value and provide paid services to the private sector. There are more than 160 operational PPP centers across the Netherlands involving over 9,800 companies, 5,000 teachers, and 84,000 students. An average PPP center engages with 35 companies and other organizations.<sup>92</sup> See [Box 9](#) for Armenia example.

**With the aim of developing the digital skills of citizens, a whole-of-society approach has been adopted and implemented in some contexts.** In Austria, economy-wide efforts to develop citizens' digital skills have been led by fit4internet, a civil society organization under the

umbrella and leadership of the Federal Ministry for Digital and Economic Affairs and a member of the [Digital Skills and Jobs Coalition](#). It has successfully facilitated (and enabled) the confident use of digital technologies by citizens of all ages, through the [full cycle development of the EU DigComp framework](#) (Standardizing—Evaluating—Qualifying—Certifying—Profiling). The association has contributed substantially to the Austrian National Coalition for Digital Skills and Jobs. It brings together a variety of stakeholders from the private and public sectors (companies, institutions, and organizations) and provides them with a platform to launch actions to upskill and raise the level of digital competence in the country. Similarly, the Institute for Future of Work (IFOW) in South Africa is committed to addressing the challenges presented by the rapidly changing nature of work. IFOW serves as a hub for multidisciplinary research, policy development, and practical solutions. With a focus on inclusivity and sustainability, the institute collaborates with experts, researchers, policymakers, and industry leaders to contribute valuable insights and strategies for navigating the digital future of work. It actively engages in education and capacity-building initiatives, fostering a culture of continuous learning

### Box 9. TUMO Armenia and TUMO Global

**The Tumo Center for Creative Technologies is an after-school learning environment for teens aged 12 to 18 years old that was set up first in Yerevan, Armenia in 2011.** Currently, over 30,000 teens have attended TUMO centers globally. In Armenia, there are 5 TUMO Hubs and over 40 TUMO Boxes for rural outreach and access. Globally, there are 9 operational TUMO Centers while several more are planned (13 new centers are due to launch in 2024-25). The Tumo program is free of charge and is open to all students. The program does not have any prerequisites, nor does it offer grades or diplomas. Instead, it helps the students to build a live portfolio of work to showcase.

**The self-paced learning process is based on students' individual preferences combined with very specific learning targets organized around 14 digital skills area, combining technology and design.** These include animation, game development, web development, digital media among others. Guided by skilled educators and mentored by industry specialists, students' complete activities in the form of tutorials, exercises, projects, and workshops in their personal learning plans via the Tumo World, a game-like virtual learning environment.

**For its international expansion, TUMO has partnered with local entities through a franchise structure, providing a cloud-based education management system (TUMO Path).** Through this cloud-based system it delivers hundreds of hours of educational content along with accompanying in-person workshops. In addition, TUMO provides ongoing support for the project, including regular capacity-building, quality assurance, and oversight. Partners are responsible for local projects and for the management of the centers, providing the locations, operating staff, and funding for the project.

**Since 2018, TUMO has partnered with a diverse group of organizations.** In Paris, TUMO partnered with the city government to run the center through an existing cultural institution *Forum Des Images*, which serves as the local operating partner. In Berlin, the project is funded by the KfW, a federal bank and operated by Accenture, which won a public tender. In Tirana, the Albanian-American Development Foundation and the city of Tirana fund the project and have created a dedicated entity to operate the project. In Kyiv, Zurich, and Beirut, private, civic-minded organizations fund and operate the centers. TUMO is actively working with future partners in both the public and private sectors across Europe, the US, Africa, Latin America, and Asia.

Source: TUMO.

and adaptability, thus playing a pivotal role in creating a resilient, innovative, and inclusive future.<sup>93</sup>

**Such ecosystem collaboration can also help to ensure more adoption and use of STEM programs by girls and women.** For example, in Poland,<sup>xxvi</sup> for over a decade, four ministries (Ministry of Science and Higher Education, Ministry of National Education, Ministry of Administration and Digitization, and Ministry of Labor and Social Policy, Government Plenipotentiary for Equal Treatment) and private institutions have been encouraging female high schoolers to pursue high education in IT and STEM fields through the Girls as Engineers! program (*Dziewczyny na politechniki!*) and the Girls go Science! program (*Dziewczyny do ścisłych!*). Over 150,000 girls have participated in these two programs, and talented female students are offered scholarships.

**PPP coalitions are taking shape to complement each partner's strengths in financing and delivering digitally**

**enabled education services.** The UK government has been actively supporting the EdTech business sector with a clear vision, guidance, and financing support mechanisms. It is working closely with EdTech businesses and key sector organizations to ensure that EdTech products match the education sector's needs. The Department of Education has partnered with the British Educational Suppliers' Association (BESA) in designing LearnED—an online platform—to match teachers with relevant quality EdTech products and help them to become more informed buyers of EdTech products. On LearnED, free trials of EdTech products are available with case studies detailing the impact of each product on school education. In collaboration with the Department for Business, Energy, and the Industrial Strategy (BEIS), F6S, and Nesta, UCL Educate—a leading research accelerator program for EdTech—has helped EdTech companies to work with schools, colleges, and higher education providers to design EdTech products aligned with the needs of educators and students.<sup>94</sup> See [Box 10](#) for Türkiye example.

#### **Box 10. Building the EdTech Ecosystem for Technological Innovations in Education in Türkiye**

Under the [World Bank's Safe Schooling and Distance Education Project in Türkiye](#), the *EdTech Hub*, *Eğitim Teknolojileri Kuluçka ve İnovasyon Merkezi* (ETKİM), was created as an incubator center in the first national Technopark as a collaboration between the Ministry of National Education, the Ministry of Technology and Industry, SMEs, and Middle East Technical University. ETKİM aims to establish an education technology ecosystem to support teaching, learning, and skills development. It will also promote the commercialization of the EdTech sector by creating public-private partnerships between entrepreneurs and industry, by engaging students and teachers with innovations, and by mobilizing researchers from tertiary education institutions. ETKİM is implemented by the Ministry of National Education's General Directorate of Innovation and Educational Technologies, with three areas of focus: (i) the preparation of technology-supported student-centered, active learning-based teaching scenarios in cooperation with teachers and academics; (ii) R&D activities, research, matching up and collaboration between ecosystem actors for the development, testing, and integration of educational technologies and materials into the educational processes; and (iii) incubation and mentoring support for entrepreneurs at the start-up level in line with the National Technology Entrepreneurship Strategy.

**The professional learning lab at the EdTech Hub established under the project is structured to support the teaching and learning of 21st century competencies.** Modeled after Europe's future classroom labs, it is supporting teachers in developing their capacity to deliver active learning and testing innovative technology-enabled pedagogical approaches. The learning lab hosts weekly workshops and training events for teachers focusing on different subjects in which teachers are trained to prepare teaching scenarios and then practice them in their own classrooms. Trainers follow up with teachers and assess them on their effectiveness. Under the project, 500 such professional labs are also being planned across the country.

**The EdTech Hub has attracted over 40 firms working on EdTech products including multimedia, gaming, interactive e-content, simulations, and virtual labs.** The interest in the Hub and demand to join from the private sector is high. There are calls to expand the Hub with new modalities to encourage investments in the development of new commercial ideas in the EdTech sector. All of these efforts are supported by an EdTech Strategy for Türkiye, prepared under the project, that is focused on identifying EdTech innovations, promoting technology use in education, strengthening ecosystem interactions, supporting EdTech entrepreneurs, empowering the skills and innovation of teachers and pedagogical staff, and mobilizing EdTech researchers from schools and universities.

Source: World Bank.

<sup>xxvi</sup> On special nationwide open days, girls visit technical universities and interact with female students majoring in technical studies and female scientists. Complementary activities, such as running experiments, are also carried out during the campaign. In addition, many more initiatives have been run to encourage girls to pursue STEM, including 'Lean in STEM', 'Girls Code Fun', and 'IT for She' (the biggest IT camp for women in Europe).

There is potential for other useful partnerships to be forged in this area. These include partnerships between universities and industry and through intra- and inter-government partnerships and cooperation between IFIs. In many developing country contexts where markets and innovation ecosystems are not well supported, there will be a need for priming and much stronger support in terms of guidance, analytics and financing mechanisms to get these partnerships off the ground. Also, while PPP arrangements may be becoming common in some HICs and MICs, they may be harder to develop in many LIC and LMIC contexts with insufficient fair market competition, limited skills supply and demand, and low governance capacity, thereby requiring considerable external support.

## 2.4 Unpacking the Layers: Digital Pathways in Education and Skills Development

Based on the conceptual framework and the elaboration of each of the four layers into potential component parts, we can put the various elements together. [Figure 9](#) presents the four layers along the depth and scale dimensions complete with their various component parts. This is by no means a fully representative view and may include or exclude some elements based on their relevance in a given context. The purpose here is not to delve into each of the component parts but to highlight the characteristics and potential of digital solutions and how they might enable and strengthen education service delivery to improve outcomes and impacts at scale for all. The unique and dynamic interactions among the various dimensions, layers, and elements suggest that countries that carefully tailor their digital pathways and related strategies and actions will likely be able to change their course effectively as technology evolves.

Overall, some countries are leading the way in learning and skills development by deepening the proactive governance of their digital transitions in education (from strategic layer all the way to the implementation layer) while collaboratively leveraging the breadth of offerings from the private sector. They have consistently updated their education vision, policies, investment strategies, and practices over several decades, embedding digital developments and keeping pace with technological changes to enhance the impact of education. Singapore, Korea, China, and several high-income EU countries such as Austria, Denmark, Estonia, and Finland not only perform well in international school-level PISA<sup>xxvii</sup> assessments (for 15 year olds) but also in adult learning assessments, such as the Programme for the International Assessment of Adult Competencies (PIACC) and in broader assessments, such as the Global Talent Competitiveness Index (GTCI). It is no

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*The unique and dynamic interactions among the various layers, and elements of the conceptual framework suggest that countries that carefully tailor their digital pathways and related strategies and actions will likely be able to change their course effectively as technology evolves.*

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coincidence that many countries that have adopted digital strategies and solutions in their education systems have also embedded and institutionalized them in their policies, practices, workflows, and daily lives as well as have deepened their links with industry and their engagement with the private sector in service to people and learning. There are also significant steps many countries are taking to address the challenges of the digital-climate nexus through education and skills development (See [Box 11](#).<sup>95</sup> Role of Education and Skills to better manage the Digital-Climate Nexus).

In the following chapter, we synthesize the available evidence on the opportunities and risks involved in choosing the right digital pathways in education and skills development sectors from a global perspective, highlighting some mitigation initiatives and reflecting on newer approaches that have become available to shape the future of evidence in service of learning and learners.



**Figure 9. Unpacking the Layers: Digital Pathways in Education and Skills Development**



Source: Author's analysis.

Note: The four layers are aligned with the core principles outlined in the [World Bank EdTech Approach paper](#): Adaptable across school and post-secondary education, NEETs, out-of-school youth and FCV contexts; Requires engagement across local, regional, national levels; Relevant across modalities, for example, tech-enabled face-to-face, blended/hybrid and fully remote modalities; Education ICT and Data Layer includes hardware, software, networking, digital content, information systems, data analytics, and related human capabilities.

### Box 11. Role of Education and Skills to Better Manage the Digital-Climate Nexus

As education systems worldwide increasingly integrate digital solutions, their environmental impact poses significant challenges. Digital pollution in education manifests in several forms. Firstly, there is the direct energy consumption of programs and devices. Secondly, the production and disposal of physical devices like tablets and smartphones significantly contribute to environmental degradation, as these devices quickly become obsolete and often end up in landfills without proper recycling. Thirdly, the continuous use of digital tools and cloud-based solutions generates substantial data traffic, consuming considerable energy resources (Racsco & Troll, 2020).

At the same time, the potential of digital technologies can be effectively harnessed to catalyze the green transition across various other sectors using relevant skills and competences delivered by the education sector. Studies underscore the importance of occupation-specific cognitive and technical skills, alongside socio-emotional and digital competencies, and sustainability practices, in meeting the demands of green jobs (OECD, 2023). Countries like India, Indonesia, and Viet Nam are already emphasizing sustainability awareness and STEM-related skills in their educational frameworks to prepare their populations for a greening economy.

Thus, situated at the intersection of digital technologies and sustainability efforts, [Green Digital Practices](#)<sup>xxviii</sup> in education and skills development are emerging as a therapeutic approach. This approach encompasses using digital solutions in the education sector to promote environmental sustainability and efforts to make digital technologies themselves more environmentally friendly. Digital solutions have an important role to play in monitoring, predicting, planning for, and responding to climate change and extreme events, and in protecting critical education infrastructure and vulnerable student populations.

The application of digital technology in education spans both climate change mitigation and adaptation efforts. *Mitigation* efforts are aimed at reducing greenhouse gas (GHG) emissions to limit the increase in the average global temperature to 1.5 degrees Celsius above preindustrial levels. *Adaptation* efforts are aimed at reducing vulnerability and exposure to climate variability, building adaptive capacity, and lowering the costs and damage from climate-related impacts and natural disasters. The following efforts collectively can be helpful to foster a more sustainable and environmentally conscious education system.

1. **Cultivating green-digital competences:** Ensure school managers, teachers, and students understand how to leverage green digital technologies, online platforms, and digital materials to enhance teaching, learning, and management.
2. **Promoting Efficient Use of Digital Tools and use of Digital Learning Materials:** Minimize energy consumption by optimizing the use of digital devices and applications, and reducing need for traditional print materials.
3. **Building sustainable digital infrastructure:** Building energy-efficient data centers, networks, devices and management systems.
4. **Implementing Eco-Friendly E-Waste Management:** Responsibly dispose of and recycle obsolete digital devices to reduce electronic waste.
5. **Leveraging Digital Tools for Sustainable Practices:** Use digital technologies to support and enhance sustainable practices within educational institutions.
6. **Integrating Environmental Sustainability into Curricula:** Embed principles of environmental sustainability into educational content to foster awareness and responsibility among students.

Many education systems have developed professional standards integrating research, digital, and green competencies to guide educators in their roles and professional development. These standards emphasize teacher agency, inquiry-based learning, action research, and collaboration as key competencies. For example, the Austral-

<sup>xxviii</sup> Green digital practices encompass knowledges and practices to make environmentally responsible decisions in digital activities.

ian Professional Standards for Teachers, developed by the Australian Institute for Teaching and School Leadership (AITSL), provide guidelines for teacher preparation and development on green digital. In Scotland and Ireland, professional standards explicitly include digital and green competencies, embedding Learning for Sustainability and Digital Literacy across all educational levels (Staring & Schleicher, 2023).

**The integration of green digital practices into the education sector is increasingly evident through various global frameworks and initiatives.** For instance, the Education 2030 Learning Compass, EU DigComp, and EU GreenComp frameworks highlight the importance of a strong foundation in science, digital skills, and positive environmental attitudes (Broberg, 2023). EU DigCompEdu framework addresses teachers' ability to develop learners' digital competence in communication, content creation, responsible technology use, and problem-solving (Redecker, 2017). Environmental and sustainability education is now embedded in curricula worldwide, with 77% of secondary schools in 85 countries including these topics in their science and social science curricula (McKenzie & Benavot, 2024). UNESCO guidelines for designing green curricula cover key areas such as climate science, ecosystems, and sustainable lifestyles (UNESCO, 2024a) while the UNESCO Green School Quality Standard (UNESCO, 2024b) and the EU Digital Education Action Plan (2021-2027) emphasize establishing green schools with energy-efficient lighting and renewable energy-powered data centers.

Source: World Bank.

# 3 DIGITAL TRANSITIONS CREATE BOTH OPPORTUNITIES AND RISKS

Countries that leverage digital solutions *can* realize equitable, fit-for-purpose, and resilient education systems with a positive impact on learning outcomes *if certain conditions are in place*. Solutions must be designed with the principles of learning and of digital development—such as inclusion, scale, and sustainability—in mind.<sup>96</sup> In this chapter, we present the current evidence landscape and discuss the limited supply of evidence on digitally enabled education interventions, which have often employed EdTech products and services. We outline the potential outcomes of the ongoing digital transitions in education systems globally, highlighting the evidence of potential opportunities, risks, and mitigation measures. The review illustrates the evidence available from low-income, middle-income, and high-income countries. We also highlight the increasing tendency of researchers and analysts to use several different methodologies to review evidence on the efficacy and effectiveness of technology use in education and share examples of policy responses in select high-income countries (HICs). We also bring forth newer approaches that should be considered for shaping the future of evidence and emphasize the key issue of a lack of globally shared standards of evidence for digitally enabled education interventions.

## 3.1 Current Evidence Landscape

Past research has consistently shown that technology is no magic bullet; it can help to improve education *if and only if certain conditions are in place informed by the science of learning and principles of digital development*.<sup>xxix,97,98</sup> It is important for education decision-makers who are contemplating investing in digitally enabled interventions in education at scale to be clear and thoughtful about why they are adopting a particular technology and to what end—and give due consideration to its realistic potential to achieve this intended goal in their particular context. This contextualization of digital solutions for teaching and learning is often essential to ensure that they are adopted by their primary users such as teachers, students, and administrators.

So far, the research literature has not kept pace with educational practice on using technology in the teaching and learning process and in pedagogical and administrative management. This lag can be attributed to sev-

eral factors: (i) the incoherence between speed and scale of technological advancements on the one hand and regulation and research on the other; (ii) the challenge of generating timely, contextually relevant, and cost-effective research that can help education decision-makers to determine the possibilities and risks of specific solutions in their context; (iii) the fact that generalized evidence is often less useful on the ground, whereas locally contextualized studies are only relevant in their specific settings; and (iv) policymakers frequently make decisions about digital adoption without demanding the necessary evidence, instead relying on political considerations, the reputation of specific innovations, and the recommendations of influential individuals.<sup>99</sup>

**Digital interventions centered on self-led learning and improvements to instruction were found to be the most effective forms of EdTech at raising learning outcomes in a recent study.** Rodriguez-Segura (2020) analyzed 67 (quasi) experimental studies across 29 LMICs since 2002. The studies were classified into four groups, with 21 being focused on access to technology, 9 on technology-enabled behavioral interventions, 17 on improvements to instruction, and 20 on self-led learning. Technology-enabled behavioral interventions were found to be less promising for generating significant effects but highly cost-effective. Although expanding access to technology alone was shown to be insufficient to improve learning, it is a necessary first step for other types of interventions. A similar meta-review done by Escueta et al (2017) that focused on HICs, found that: (i) providing access alone is insufficient; (ii) computer-assisted learning with personalization applied in math is promising; (iii) behavioral interventions such as large-scale text message campaigns are promising; and (iv) research on online learning is inadequate.

**A study that applied the SAMR<sup>xxx</sup> model to 1,640 technology-related interventions found that most of them used technology to augment (46 percent) or modify (34 percent) the educational experience, with relatively fewer aiming for technology substitution (15 percent) or redefinition (5 percent).** Vegas et al (2019) found that, out of all of the interventions, only 11 percent were evaluated externally, while 18 percent were evaluated internally, highlighting that research only captures a small snapshot of the EdTech sector. Only 26 EdTech innovations were

xxix: Released in 2014, the Educational Technology Topic Guide may be considered foundational, covering 83 resources (45 research documents, 20 literature reviews, and 18 gray literature reports) on EdTech use in schools in LMICs (Power et al. 2014). The guide reviewed a range of EdTech uses and initiatives, including IRL, audio or video resources, student tablets and e-readers, computer-assisted learning, computer suites, and one laptop per child. Since then, the Educational Technology Map was developed, covering 401 resources in low-resource settings, including 279 observational studies, 81 quasi-experimental studies, 23 experimental studies, and 6 secondary studies (Hollow, Muyoya, and Brugha, 2016). The study shares a useful interactive educational technology database that assists in visualizing data.

xxx: The SAMR model developed by Ruben Puentedura in 2006 can help educators think about the role of technology in supporting learning. Substitution can be thought of as substituting an analog method, such as quizzes on paper, with a digital version. Augmentation implies an improvement of a function, such as automatically graded worksheets, freeing up teachers' time. Modification allows for significant task redesign, such as long-distance peer learning or dual teacher broadcast model. Redefinition means that the use of technology creates an experience that was previously inconceivable. An example is dividing students into groups and having them collaborate on a video tutorial or content creation.

evaluated using randomized control trials (RCTs). Regarding goals, 84 percent focused on improving students' skills; 24 percent on increasing access, attendance, completion, and enrollment; 23 percent on improving teaching; and 7 percent on increasing administrative efficiency. In terms of implementors, 46 percent were implemented by NGOs and 40 percent by the private sector, while governments made up only 11 percent, and 3 percent were collaborations. Notably, students from low-income households and those from rural areas were the largest groups served by EdTech solutions. An overwhelming majority of EdTech innovations (84 percent) focused on improving students' skills, whether cognitive or socioemotional, with the top three skills areas being literacy, 21st century skills, and numeracy.

**Another study found that the presence of technology can benefit student achievement and improve various pedagogical aspects.** Bernard et al (2018) identified 20 meta-analyses of sufficient methodological quality and found:

- The presence of technology can benefit student achievement, even if the magnitude of its effect is not staggeringly high. This benefit extends across the grade levels from elementary education to graduate school education.
- Various pedagogical aspects of technology use are very effective. These include cognitive support tools and applications (that is, tools predominantly in the hands of students intended to intensify and structure their interaction with the content to be learned<sup>100</sup>), the role that the quality and fidelity of the treatment implementation process plays in affecting learning outcomes,<sup>101</sup> the importance of teacher training and professional development,<sup>102</sup> the added value of embedded assessments,<sup>103</sup> the importance of matching interventions to the needs of the target population (for example, multimedia for children from less stimulating family environments<sup>104</sup>), and the effectiveness of using technology in combination with other meaningful learning activities.<sup>105</sup>
- The moderate use of technology has been shown to outweigh technology applications that feature all of the bells and whistles.<sup>106</sup>

**As the evidence base grows, systematic reviews and meta-analyses—particularly in high-income contexts—have shifted from general summaries to examinations of specific digital interventions.** These include educational radio, interactive radio instruction (IRI), interactive voice response (IVR), educational television, digital personalized learning, gamified learning, accelerated learning,

tech for education in emergencies (EiEs), tech-supported teacher professional development (TPD), tech for learners with disabilities, massive open online courses (MOOCs), blended learning, and voice response (VR) for education. Another good resource for EdTech research is a 2023 Technology in Education database, which has over 117 systematic reviews and meta-analyses on a variety of subtopics (<https://tech.eved.io/lib/>). Notably, 34 were done between 2020 and 2022, highlighting the increase in number of studies and the impact of distance learning during the COVID-19 pandemic on EdTech research.

## 3.2 Diving into the Potential Opportunities

**This section outlines six potential outcomes of digital transitions in education.** It maps the evidence on the extent to which these outcomes have been or can be realized and on what has hindered their realization and discusses the recommendations suggested in the literature. While a growing number of evidence reviews (for example, rapid evidence reviews, meta-analyses, and systematic reviews) study the impacts of digital interventions in education, there are relatively few rigorous evaluations using experimental studies that offer robust evidence.<sup>107</sup> Several observational and quasi-experimental studies have been undertaken on a wide range and variety of education interventions to better understand the impact of the use of technology on education.<sup>108</sup> At the same time, newer methodological approaches to EdTech evaluations are emerging. A selection is presented in this section. The evidence reviewed in this section was gathered through searches of existing evidence libraries (<https://education-evidence.io/>) and resources shared by experts.

### 3.2.1 Equitable Access to Quality Learning for All

**Government-led technology-enabled education programs need to reach and help the most vulnerable, economically poor, and socially and politically marginalized people in the most difficult contexts.**<sup>109</sup> The Incheon Declaration for Education 2030, which was adopted in 2015 at the World Education Forum in Incheon, South Korea, commits to addressing all forms of exclusion and marginalization in education, emphasizing that “no education target should be considered met unless met by all.”<sup>110</sup> This includes young people who are not in school, learners with disabilities, girls and women who live in oppressive environments, refugees and internally displaced persons, persons in emergency or fragile contexts and experiencing natural disasters, disadvantaged ethnic and religious minorities and indigenous peoples, and people who live in resource-constrained rural and remote areas and low-income households (See [Box 12](#) on Ukraine example).<sup>111</sup>



### Box 12. Ukraine's Expansion of Digitally Enabled Education in the Midst of War

Since Russia's invasion of Ukraine began, online learning remains a defining feature of the Ukrainian education system. The FCV context in Ukraine is uniquely shaping the organization of online learning, with digital devices being the only bridge to education for many children. In directly affected regions, especially in the east and south of the country, most schools are providing only online classes for security reasons. For instance, as of February 2024, only 5 percent of the 50,000 students in Kharkiv can study in person, primarily from classrooms set up in metro stations. Meanwhile, educational institutions farther away from the frontlines are only permitted to resume regular operations if they have access to bomb shelters capable of accommodating all students and staff in the event of an air alarm. As a result, a quarter of all school students remain dependent on online learning – with many studying remotely since the beginning of the COVID-19 pandemic in 2020.

**Partnerships for digitalization and remote learning are essential for implementing the broader education strategy of ensuring access to learning.** The key priority of the Ministry of Education and Science of Ukraine (MoES) has been to ensure access to education for all students. In addition to supporting the construction of thousands of bomb shelters in schools, the MoES has fostered international and local partnerships to provide access to online education, especially in areas closer to the frontlines. It has coordinated the delivery of more than 130,000 devices to teachers and students from different partners and donors. In addition, authorities are collaborating with partners on the ground to establish digital learning centers (DLCs), which are serving as safe spaces for students to access distance learning content. The MoES is developing DLCs in some areas, those that have suffered considerable levels of destruction, and communities hosting many internally displaced children. Close to 300 DLCs have been established or are under development.

**As part of its strategy to build the education system back better after the war, Ukraine is using digitalization to complement and support safe and quality face-to-face education with tools such as the [All-Ukrainian Online School \(AUSO\)](#).** The AUSO is the core learning management system in Ukraine, providing access to more than 4,000 lessons, tests, and materials covering 18 subjects for students in grades 5 to 11. Each AUSO lesson is thoroughly assessed for compliance with the curriculum. While this platform remains primarily an online content repository for self-study, it has evolved since the beginning of the war to offer new functionalities that complement teachers' instruction for both in-person and online classrooms. For instance, the AUSO provides methodical support to teachers, including courses and other professional development opportunities certified by the MoES. The platform also features a Teacher's Cabinet, which enables teachers to design online courses as well as carry out diagnostic pre-tests in mathematics and Ukrainian language. The overall aim of the MoES is to build the resilience of the education system to ensure the continued relevance of digitalization in the future. Thus, while mobilizing the rapid deployment of digital devices and digital learning resources, the MoES is prioritizing the use of digitalization to enable the long-term recovery of the education system.

Source: World Bank.

**To promote equitable benefits and meaningful access, technology-enabled education interventions must provide adequate support for marginalized learners.<sup>112</sup>**

Electricity, physical ICT infrastructure, connectivity, and devices are all required for meaningful access. Meaningful connectivity means having access to speeds similar to 4G, an appropriate device, an unlimited broadband connection, and the opportunity for daily use.<sup>113</sup> However, having access to technology is not enough. Sociopolitical factors such as language, culture, literacy, community, and institutional factors need to be considered to ensure adequate access.<sup>114</sup> To promote equitable access for all learners, learning, tutoring, and assessment systems must be designed in their own languages. More than half of the material on the web is written in English, which makes

it hard to find useful tools that are not English-only. However, advances in natural language processing (NLP) models hold promise for substantially improving machine translation capabilities. This is exemplified by tools such as DeepL, which can produce translations that closely resemble those made by humans, albeit in a limited set of languages.

**Education data is predictive in addition to being adaptive.** Early warning systems can track student attendance, behavior, and performance, and [detect or predict students likely to drop out or fall behind better](#) than other systems, such as those based on regression analysis. Some platforms can track student behavior (for example, time taken to answer questions), compare them to other users' per-

formance, determine the probability of a student passing a quiz, and determine what can be done to increase the odds of success. These predictive systems also have real-time capability to analyze data on student performance and generate actionable recommendations for personalized learning. For example, a study of Knewton online courses conducted by the Center for Research and Reform in Education (CRRE) at Johns Hopkins University found a positive correlation between student use of these courses and online assessment of learning performance, irrespective of learning ability.<sup>115</sup>

**Similarly, effective use of technology in education goes beyond basic digital competence to data literacy, critical digital literacy, and the ability to overcome socio-technological barriers.** Some socio-technological obstacles to the use of technology by students that were identified in research conducted in Bangladesh, Pakistan, Kenya, and Ghana comprise restricted time to use devices, a lack of confidence in technology, inadequate digital literacy among parents and learners, inadequate support, fears about privacy, insufficient awareness and promotion of digital education offerings, and preconceived notions about social media and entertainment.<sup>116</sup>

**To ensure an equitable distribution of benefits, it is necessary to consider various personal and socioeconomic factors, including household income, geographic location, occupation, gender, and age.**<sup>117</sup> Different people have different learning experiences depending on their level of digital knowledge, language skills, and ability to learn independently.<sup>118</sup> To meet the specific needs of each learner fairly, it is important to offer ongoing support, to integrate (tech-supported) teaching at the right level, and to help students to develop self-directed learning abilities. Offline capabilities, captions, transcripts, responsive design that adapts to different screen sizes, short video lengths, and integration with familiar technologies (for example, WhatsApp) whenever feasible are technological recommendations that promote equitable benefit (as seen in South Africa<sup>119</sup>). Offering data bundles and zero-rating by telecommunication providers and the government are also good ways to lower data costs, particularly in LMICs.<sup>120</sup>

**A significant proportion of studies on the use of digitally enabled education to assist marginalized communities has concentrated on technology-supported girls' education.** According to a rapid evidence review of 39 papers by Webb et al (2020, p. 13-14), "girls benefit more than boys from the use of technology when provided with access to it." It was also discovered that "girls are likely to respond with a high level of engagement when given access." However, girls still do not have as much access to EdTech as boys because of cultural, religious, and gender-based norms about work distribution and first preference.<sup>121</sup>

**One of the greatest sources of untapped potential in technology is providing learners with special needs and disabilities (SND) opportunities for remote learning, flexible learning times, and accessibility tools such as captioning, screen reading, speech-to-text tools, and braille displays.**<sup>122</sup> A systematic literature review covering 187 studies on EdTech for learners with disabilities in LMICs found that only few studies had addressed the impact of EdTech on learning outcomes or other key functional skills but instead focused on engagement.<sup>123</sup> The technologies used included social media for communication, software programs, and apps intentionally designed for learners with disabilities, sign language apps to teach mathematics, and low-vision devices.<sup>124</sup> The existing studies focus on sensory impairments rather than learning disabilities, are limited to a few dominant languages (particularly English), and are mainly conducted in special schools (in HICs<sup>125</sup> and LMICs<sup>126/127</sup>). Hersh and Mouroutsou (2019) raised concerns that a "bring your own device" model—although providing students with device continuity—may further exclude less well-off SND learners.

**Technology provides crucial opportunities to deliver education in emergency and refugee contexts that may not otherwise be possible.** While rigorous evidence is limited, certain characteristics of effective technology use in education have been identified. These include enabling mobile learning for students on the move; providing multimodal access on SMS, radio, mobile phones, and (preloaded) tablets; supporting continuous TPD; providing psychosocial support; streamlining education data collection; and using community-based practices when learning is likely to be happening outside of classroom settings.<sup>128</sup> Recommendations from Dahya (2016) for education in emergency (EiE) contexts include focusing on procuring and maintaining technology locally, clearly defining the purpose of technology, aiming to strengthen the education system, ensuring privacy and preventing harm, and looking for partners in other sectors (for example, in the health sector). Ensuring higher education continuity opportunities can be particularly rewarding for refugees and internally displaced populations. (See [Box 13](#)<sup>129</sup> University of the People, a tuition free Online University).

**Academic recovery programs can be enabled by digital technology but results so far have been mixed (see examples in Indonesia<sup>130</sup> and Türkiye<sup>131</sup>).** In LMICs, such programs support over-age or out-of-school children who have fallen behind because of having to work to support their families, the cost of schooling, being refugees, or being too old to enroll in basic education.<sup>132</sup> These programs aim to improve socioemotional well-being, self-confidence, and self-regulated learning.<sup>133</sup> In the Eastern Caribbean, a promising academic recovery program uses EdTech in integrated ways, such as open educa-

**Box 13. University of the People: Fully Online Higher Education for the Underserved and Refugees**

**University of the People (UoPeople)**, founded in 2009 and accredited in 2014, is a pioneering non-profit, tuition-free online university. It offers undergraduate and graduate programs in Business Administration, Computer Science, Health Science, Information Technology, and Education to students worldwide. UoPeople's most notable feature is its tuition-free model, where students only pay minimal exam fees rather than traditional tuition, which makes higher education globally accessible, especially for vulnerable and disadvantaged. The innovative online delivery model has attracted students from over 200 countries, reaching underserved populations in the developing world. Additionally, UoPeople's partnerships with institutions such as the University of Edinburgh and New York University, along with UN organizations like UNESCO, UNICEF, and UNHCR, have facilitated academic and professional development opportunities and numerous scholarships for at-risk populations. [Founder](#) and President Shai Reshef was honored with the [2023 Yidan Prize for Education Development](#) for UoPeople's role in breaking down barriers to higher education globally.

**UoPeople prioritizes educational access for refugees, serving over 137,000 students, including 16,500 refugees, and focuses on equipping students with technical skills for the high-tech industry.** Through partnerships with UNHCR and the German and U.S. governments, UoPeople offers scholarships to Syrian refugees and students in Burkina Faso, providing higher education opportunities to those otherwise without access. In 2020, UoPeople launched an Arabic program offering Business Administration degrees to support Arabic-speaking refugees, including English courses and employing refugees in administrative and academic roles within the program. Additionally, UoPeople is introducing the world's first tuition-free, 100% online Master of Science in Information Technology (MSIT) degree program to equip students with essential skills for the tech industry, aiming to bridge the gap between technology and management.

**Despite its innovative approach to improving access for all, UoPeople also faces challenges.** The reliance on peer-to-peer technologies, rather than traditional teaching faculty, is effective only if interactions are meaningful leading to some skepticism about education quality compared to that in traditional institutions. The lack of a physical campus and face-to-face interaction may raise concerns about the depth of student learning. Limited program offerings compared to established universities potentially restrict students' choices for specialized or advanced degrees. Furthermore, debates continue about the recognition of UoPeople degrees by employers and academic institutions, potentially affecting graduates' job prospects. Lastly, while UoPeople's low-cost model aims to enhance accessibility, its long-term sustainability is uncertain due to heavy reliance on donations, partnerships, and exams. However, the pandemic experience has helped temper many of these concerns and validate the relevance of this approach.

Source: Yidan Prize 2023; Oded, Y. 2019; Kalman, Y.M. 2010.

tional resources (OER), to support learning and WhatsApp to provide psychosocial support, but the program has not yet been externally evaluated.

**Distance learning through educational radio, interactive radio instruction (IRI), and interactive voice response (IVR) can provide access to learning opportunities for students in rural and remote areas.** Educational radio supports language learning more effectively than mathematics.<sup>134</sup> Radio is also cost-effective and, when used interactively in groups, can provide a better pedagogical experience for undertrained teachers (Sierra Leone, Liberia, Zambia, and South Sudan<sup>135/136</sup>). The Somali IRI Program (SIRIP) was found to increase enrollment and improve students' test scores.<sup>137</sup> More recently, the Rising on Air program in Sierra Leone and Liberia used a com-

bination of radio, phone, and SMS to provide interactive education during the Ebola and COVID-19 pandemics.<sup>138</sup> Evidence on IVR is less conclusive. An study of an IVR program in Bangladesh reported large learning gains (0.65 SD or 0.64 LAYS<sup>139,xxx</sup>),<sup>140</sup> but a study in Ghana where the Rising on Air program was adapted to IVR, found no significant effects on learning.<sup>141</sup> While IVR enables more interactivity than is usually possible in LMICs, its costs vary depending on telecommunications service providers within the country.

**A rapid evidence review of educational television found that it has the potential to improve learning outcomes, socioemotional outcomes, and social reasoning in low-income contexts and hard-to-reach areas.**<sup>142</sup> Regarding social reasoning, educational television can help stu-

dents to deal with different emotions and situations as well as learn about different religions and cultures, different disabilities, and stigmatized groups (for example, people with albinism or HIV).<sup>143</sup> If designed to include sign language and culturally diverse content and languages, it can also support hard-of-hearing learners and minority groups.<sup>144</sup>

**Text, instant messaging apps, and chatbots can support learning, interaction, and collaboration of students and teachers in low-tech ways.** Messaging-based programs can support learning through peer tutoring, collaborative learning, delivery of content, teaching, and assessment.<sup>145</sup> SMS-based content produced positive learning gains and increased parental engagement in the MobiLiteracy Uganda Program and a rapid trial in Botswana.<sup>146</sup> The Dr. Math function on the Mxit messaging and social media app in South Africa provided users with interactive text-based learning opportunities and connections to peer tutors.<sup>147</sup> Despite the positive experience at the time, the drop in the popularity of Mxit has led experts to recommend that content and program design should not be tied to any particular platform.<sup>148</sup> WhatsApp, which is currently more popular, has been used in a variety of formal learning programs as well as hosting spontaneous peer support groups for collaborative learning (in South Africa, Türkiye, Brazil,<sup>149</sup> and Lebanese refugee camps<sup>150</sup>). While WhatsApp allows for sharing text messages, images, videos, and voice notes, its drawbacks include message flooding, a lack of separation from general WhatsApp use, and eye strain.<sup>151</sup> While the use of instant messaging platforms in LMICs deepens the personal nature of interactions, collaboration, and socioemotional support (as in the Zataari refugee camp in Jordan<sup>152</sup>), institutions and individuals in HICs typically prefer to maintain a clear separation between their personal and professional life, as evidenced by strict data protection policies in businesses that limit employees' personal instant messaging use.<sup>153</sup>

### 3.2.2 Better Learning Outcomes and More Holistic Learning Opportunities

**Increases in school enrollment rates over the past few decades have shown that schooling cannot be automatically equated with learning.**<sup>154</sup> The global learning crisis has been exacerbated by the COVID-19 pandemic, resulting in further learning losses. While there is a global need to improve learning outcomes, particularly in foundational literacy and numeracy, the broader “citizen-focused” outcomes of learning—namely its social, cultural, and political awareness and knowledge—should not be forgotten or be limited to a select, privileged few.<sup>155</sup> Learning should encompass lifelong learning, global citizenship, socioemotional development, and the development of curious, creative, critical, and socially conscious populations.<sup>156</sup>

**A systemic review of 91 causal studies on the impact of technology use on learning outcomes found positive effects across a range of instruction types.** The types of technology studied included: (i) video-based instruction; (ii) online courses; (iii) computer-assisted instruction; (iv) mobile devices; (v) simulations; (vi) animations; (vii) games; and (viii) flipped classrooms.<sup>157</sup> These positive effects were found when technology leveraged effective learning principles.<sup>158</sup> They were also observed when technology provided unique learning experiences that were not available through traditional teaching (in line with the findings of Power et al, 2014), particularly when it saved time and facilitated recall, revision, or testing through practice questions, quizzes, or problem-solving activities. Conversely, technology hindered learning when there were no opportunities to discuss or consult about what was being learned, when unrestricted access meant students only looked at materials before exams, and when interventions prioritized access to technology over its effective use.

**Since the COVID-19 pandemic, many educational institutions have incorporated blended learning into their teaching methods to build their resilience in case of further crises.** A meta-analysis of blended learning in higher education found that students could have achieved 13 percent more if they had access to it.<sup>159</sup> The meta-analysis also found that the providing technological support (as opposed to content support) and increasing student-teacher-content interactions further increased learning gains. A similar meta-analysis by Means et al (2013) of 50 independent effect sizes found 11 effect sizes to be significantly positive toward online or blended learning models and three effect sizes to be significantly negative in favor of face-to-face learning. The overarching finding was that online and/or blended learning can produce stronger learning outcomes. However, the authors emphasized that non-technological pedagogical elements of blended learning models such as additional learning time, instructional resources, and course elements (or confounding variables) may play a larger role in achieving positive outcomes.<sup>160</sup> Blended teaching and learning approaches are particularly relevant for STEM education (See [Box 14](#): Use of ICAP Learning Framework in STEM Education).<sup>161</sup>

**Consistent with GEEAP “smart buys” recommendation,<sup>162</sup> a meta-analysis of the effectiveness of technology-supported personalized learning in LMICs covering 16 randomized control trials (RCTs) found a statistically significant—if moderate—positive effect size of 0.18 on learning ( $p = 0.001$ ).**<sup>163</sup> The study found that mathematics and literacy interventions have similar effectiveness, that the presence of teachers played a key role in the personalization of learning, and that different lengths and intensities of learning content appear to have had similar positive effects. A broader meta-analysis reviewing 34 studies



### Box 14. Use of ICAP Learning Framework in STEM Education

ICAP (Interactive, Constructive, Active, and Passive) learning framework is a well-recognized model to categorize and scaffold student engagement based on cognitive processes involved in learning. [Micheline T. H. Chi](#) received the prestigious [Yidan Prize for Education Research 2023](#) for the practical and easy applicability of ICAP in teaching and learning. ICAP framework is built around four levels of learner engagement—passive, active, constructive, and interactive—each linked to specific knowledge-change processes that lead to varying cognitive outcomes. In the passive mode, students merely store information, leading to limited cognitive outcomes. The active mode involves integrating new information with existing knowledge through activities like note-taking, which improves recall and application. In the constructive mode, students create new outputs, enhancing their understanding through inference and leading to a well-organized construction of new knowledge. The interactive mode fosters collaborative learning through dialogue, where students co-infer, resulting in the most dynamic and robust understanding (Chi & Wylie, 2014).

**The use of the ICAP learning framework is relevant for educators in curriculum development and course design. It is especially useful for designing blended programs in STEM (Science, Technology, Engineering, and Mathematics) education.** Given the experimental, interdisciplinary and inquiry-based learning required in STEM subjects, ICAP supports educators in designing activities that advance students from passive receivers to active participants to creators and collaborators, thereby deepening their problem-solving abilities. At the same time, use of ICAP can support the creation of adaptive learning environments that address diverse learner needs, help enhance the flexibility and scalability offered by digital tools, improve access to high-quality resources and promote deeper understanding of complex STEM concepts through practical application and collaborative learning (Eugenijus, 2023). ICAP provides a clear method for observing and assessing student interactions with learning materials and peers, allowing educators to tailor instructional strategies that emphasize practical applications. In blended learning environments, ICAP can help ensure thoughtful integration of online and face-to-face learning by guiding the design of activities that combine interactive and problem-solving tasks in the classroom with online content (Chi & Wylie, 2014; Wu et al., 2023).

**In practice, new advanced systems using ICAP framework and AI-driven computer vision technology have been developed to closely monitor and categorize learners' behaviors, and respond with adaptive learning trajectories for STEM blended learning and teaching.** Specifically, the Real-time Automated STEM Engagement Detection System (RASEDS) and Precision Education-based Timely Intervention System (PETIS) have been designed to analyze students' learning processes captured by cameras. These two systems utilize object detection to identify images of learners' hands and the learning materials in use. The interactions between hands and learning materials are measured as indicators of learners' immediate behaviors, which are mapped to the ICAP framework to assess engagement levels during STEM activities.

- *RASEDS, used in STEM workshops and Internet of Things (IoT) projects, detects learners' hands and materials every 5 seconds, summarizing engagement indicators each minute.* The predominant engagement level within that minute is recorded to guide adaptive learning recommendations. This real-time, automated approach has been shown to significantly enhance engagement and self-efficacy in STEM activities by tailoring learning materials to individual needs.
- *PETIS, applied in computer programming courses, tracks student engagement every 5 seconds over 5-minute intervals to identify when students are struggling.* It records video and statistical data, enabling instructors to make informed decisions if immediate feedback and assistance are needed. PETIS not only helps address students' learning difficulties but also provides valuable insights for curricular improvements, leading to significant gains in learners' programming skills in K-12 education.

Source: Chi, M. T., & Wylie, R., 2014; Eugenijus, L., 2023; Lee, H. Y. et al. 2023; Wu, T. T. et al. 2023.

found medium effect sizes on learning achievements ( $ES = 0.673$ ) and learning perceptions ( $ES = 0.259$ ), implying that technology-supported personalized learning is more effective than conventional learning.<sup>164</sup> However, learning

methods and personalized learning software significantly moderated the effect sizes. Thus, focusing on these moderating factors can lead to greater learning gains. Another meta-analysis of 33 research studies suggested that ALEKS



(a personalized learning software in Latin America) was especially effective when supplementing traditional instruction in mathematics across various levels of education.<sup>165</sup> A longitudinal study examined the influence of MATHia, Carnegie Learning's AI-based tool, on the performance of 1 million students in algebra, particularly Black, Latino, English learner-designated, poverty-stricken, and female students. The study found that completing more workspaces in MATHia leads to better performance in algebra, particularly by students with low test scores in middle school.<sup>166</sup>

**Digital game-based learning and serious games can encourage playful, curious, and creative learning experiences. These are among the most rigorously researched subtopics in EdTech, with a minimum of 20 nuanced meta-analyses of game-based learning available.** A meta-analysis using 154 effect sizes found that scaffolding could improve learning and is more effective in adventure, puzzle, and simulation games than in role playing and strategy games.<sup>167</sup> Four reviews found mixed effects on serious games (that is, combining serious aspects and pedagogical value into fun gamified learning) and reviewed perceptual, cognitive, behavioral, affective, and motivational impacts/outcomes.<sup>168</sup> Four meta-analyses on mathematics games found improved learning outcomes, with significant heterogeneity across studies.<sup>169</sup> Regarding the impact of video games on perceptual, attentional, and cognitive skills, a meta-analysis found positive effect sizes (0.55 SD), but these were reduced in the long term (0.34 SD).<sup>170</sup>

**Phone-based, virtual, and intelligent tutoring systems are another area in which technology provides learners with greater access at scale.** There are several pedagogical benefits of high-dosage group tutoring, which technology can enhance through careful design and by leveraging the unique attributes of connectivity, interactivity, multimedia, and data processing. LMICs used SMS and WhatsApp during COVID-19 to facilitate learning recovery.<sup>171</sup> Virtual coaching can be scaled up cost-effectively and support learning engagement, rapid feedback, teaching at the right level, and more time on task. Intelligent tutoring systems (ITS) can support real-time dynamic responses to specific learning gaps and increase students' anonymity, along with automated real-time data processing, enabling nimble adjustments as well as mentoring relationships and human connection opportunities. Virtual AI-driven tutors, such as Knewton, understand students' strengths and weaknesses and help them to learn new concepts and master old ones independently. They offer customized learning content and adaptive assessment tools to increase students' engagement and improve their learning outcomes. Khanmigo is an AI-powered assistant that functions both as a virtual tutor for students and a classroom assistant for teachers.<sup>172</sup>

**ITS and virtual tutoring show promising results, especially in terms of cost-effectiveness.** Three meta-analyses show varied effects of ITS over time ( $g = 0.01$  to  $g = 0.09$ ;<sup>173</sup> 0.66 SD;<sup>174</sup> 0.6 SD<sup>175</sup>). Steenbergen-Hu and Cooper (2013) found that interventions of less than a year-long were more effective and that the general population benefited more than low-performing learners. When ITS was compared with traditional instruction alone (that is, no human tutors), large effect sizes of 0.86 SD were found. Two virtual tutoring programs implemented in Italy and Spain during the COVID-19 health emergency when children were in lockdown have been evaluated and found to have large positive effects.<sup>176</sup> Similarly, SMS-based and phone-based tutoring in low-resource settings has been found to be effective.<sup>177</sup> Virtual tutoring for language learning,<sup>178</sup> peer tutoring through mobile apps that match tutors to students,<sup>179</sup> and group online tutoring with instructors and peers<sup>180</sup> have also had positive outcomes.

**Virtual reality (VR), augmented reality (AR), and mixed reality (MR) have the potential to create immersive teaching and learning experiences.** Research on virtual reality in K-12 dates back to the 1990s,<sup>181</sup> but since then, the affordability of VR devices has increased, particularly due to mobile phone compatibility. In parallel, the field of VR instructional design is maturing. Pellas et al (2021) categorized emerging instructional design strategies, namely, activity-based, discovery, experiential, and collaborative, as well as instructional design techniques, namely, educational games, field trips, observations, role play, and simulation. Increased motivation and engagement from students as well as improved learning outcomes were observed in various studies. Drawbacks included simulator sickness, overloading students, distractedness, and complexity of functionality.

**With the growing role being played by digital technology in education, digitally enabled pedagogies that support creativity, curiosity, critical thinking, and self-directed learning have emerged.** Examples include connectivism<sup>182</sup> and rhizomatic learning,<sup>183</sup> both of which involve real-time constructed and negotiated learning through networks. Open educational practices and critical praxis promote epistemic diversity and encourage reflection on personal positions and subjectivity.<sup>184</sup> Virtual exchange programs have been found to cultivate global citizenship among learners by connecting teachers and learners to diverse people, cultures, and experiences. Critical digital literacy skills are essential in preparing students for the digital age.

### 3.2.3 Increased Effectiveness of Teachers and Teaching methods

**Effective teacher professional development (TPD) leverages the knowledge and skills of educators, integrates**

**pedagogies and subject-specific information, caters to teachers' unique and situational requirements, and helps them to meet the varied needs of their students.**<sup>185</sup>

TPD should be modeling and practice-based, provide secure learning environments, encourage discussion and critical reflection, and be teacher-led.<sup>186</sup> TPD should be sustainably implemented through regular sessions, incorporate time for professional development, and align with national policies, objectives, and assessment frameworks.

**Digital content packs and software applications can significantly enhance educators' subject knowledge and pedagogical expertise.** They are especially helpful for developing knowledge of mathematics and science and increasing language proficiency among teachers.<sup>187</sup> In contexts such as rural areas and during crises when it may be difficult to provide TPD activities, digitalized text-based and audiovisual teaching and learning materials, (scripted) lesson plans, structured guides, teaching and coaching applications, teacher learning management systems, and preloaded devices have been found to be useful. For example, English in Action and other nationally scaled mobile learning TPD programs in Bangladesh have combined school-based support with audiovisual content already loaded on memory cards or Apple iPods.<sup>188</sup> In a similar vein, the degree to which subject-specific software such as Geogebra<sup>189</sup> and MATLAB<sup>190</sup> have aided in the development of teachers' abilities has varied when implemented with support structures.

**Self-study and virtual learning communities are being implemented as online and blended learning opportunities to assist with TPD.**<sup>191</sup> MOOCs have provided new avenues and topics for teachers to upgrade their knowledge and skills (for example, in China,<sup>192</sup> India,<sup>193</sup> and Uganda<sup>194</sup>), particularly in challenging-to-access environments.<sup>195</sup> However, to use MOOCs to provide TPD, the teachers must be self-motivated, have the capacity to contextualize general content, and have adequate internet access. This is easier for teachers from higher socioeconomic groups than for those who are less well-off.<sup>196</sup> Blended or wrapped courses designed to cater to a particular group of teachers have proven to be more effective because of the provision of contextualization and support (as in Lebanon<sup>197</sup> and Kenya<sup>198</sup>). In 33 studies, most covering HICs, flipped learning in teacher education has been demonstrated to be more experiential and interactive than traditional methods.<sup>199</sup>

**Virtual or hybrid communities of practices (CoPs) foster collaborative learning among teachers and are particularly useful to provide those in fragile settings with socioemotional support, communication, and resource sharing.**<sup>200</sup> CoPs can be organized formally or organically. During COVID-19, 54 percent of 20,679 teachers sur-

veyed in over 165 countries engaged with a CoP weekly.<sup>201</sup> While informally organized CoPs are driven by teachers' needs and tend to be safe spaces, the lack of experts or moderators can result in the circulation of misinformation or encourage negative teaching practices.<sup>202</sup> Virtual CoPs occur in a range of formats, such as instant messaging platforms (Indonesia<sup>203</sup>), Facebook (Kenya<sup>204</sup>), wiki forums (Mexico<sup>205</sup>), Twitter,<sup>206</sup> and Instagram (Türkiye<sup>207</sup>). CoPs have also been created as a forum for virtual exchanges between teacher groups from different countries, allowing for inter-country sharing of practices, for challenging norms and beliefs, and for self-reflection.<sup>208</sup> Using technology in CoPs can facilitate post-training activities (South Africa<sup>209</sup>), teacher attendance monitoring (India<sup>210</sup>), and extended support (Indonesia<sup>211</sup>).

**Virtual coaching is a cost-effective solution for TPD but is less sustainable than hybrid coaching as its effectiveness can be diluted over time. This was the case in the virtual (tele-) coaching programs in South Africa<sup>212</sup> and Senegal.**<sup>213</sup> A meta-analysis of 60 coaching studies in HICs by Kraft et al (2018) found large positive effects on instruction (0.49 SD) and smaller positive effects on achievement (0.18 SD), with no significant effect sizes between in-person and virtual models. Virtual coaching on Skype was also found to be cost-effective (US\$2.40 per person) to support pedagogical leaders in Brazil<sup>214</sup>. Virtual coaching via text has been used to reinforce new practices and send reminders and nudges in Kenya<sup>215</sup> and Malawi.<sup>216</sup> While useful, it lacks key coaching elements such as observation and feedback, which are difficult to do via text.<sup>217</sup> More recently, coaching software has been developed, such as Tangerine: Coach and Tusome's National Tablets that provide built-in observation protocols, automated feedback, and post-observation discussion prompts as well as support real-time data collection (as in Kenya<sup>218</sup> and Uganda<sup>219</sup>). Research in Rwanda has examined the use of semiautomated chatbots on WhatsApp or Telegram to provide teachers with micro-content, activities, support, reminders, and motivation.<sup>220</sup>

**Technology provides novel models for teachers to gain feedback.** The use of videos for modeling or microteaching was observed in 43 percent of the 170 studies reviewed by Hennessy et al (2022) and found to be highly effective. For example, Funda Wande in South Africa has a range of videos for microteaching in a variety of local languages. Video-based reflection and opportunities to practice newly learned pedagogies improved teaching in the OER4Schools program in Zambia.<sup>221</sup> Not only do teachers see videos of exemplary teachers but they can also record themselves or their peers and self-evaluate (Türkiye<sup>222</sup> and Cambodia<sup>223</sup>). Caution should be exercised with the recording approach to ensure that teachers are comfortable and that the approach is aligned with cultural norms and practices.

**Technology has helped teachers to increase their socio-emotional learning, but it can also be a cause of anxiety.** The Dream-a-Dream program in India has worked with over 12,000 teachers from low-cost schools to increase teachers' authenticity and empathy through monthly online workshops.<sup>224</sup> The teachers gained more self-efficacy, creativity, communication, empathy, and emotional regulation, which improved their students' all-round outcomes.<sup>225</sup> However, a review of teacher stress related to the use of EdTech showed that teachers are experiencing high stress and anxiety because of being overloaded, unprepared for using technology, feelings of incompetence, faulty software, burnout, and striving for perfection.<sup>226</sup>

### 3.2.4 Cost-efficiency and Cost-effectiveness of Investments

**Evidence on the cost-effectiveness of EdTech is weak.** This is mainly because: (i) many evaluations lack cost data, and when they do exist, it is difficult to determine the true total cost of implementation and (ii) the frameworks to measure cost-effectiveness are varied and complex, making it difficult to compare different cost-effectiveness calculations when they do exist.<sup>227</sup> However, there are some studies from which lessons can be drawn.

**Using text messages or videos to provide information (otherwise known as nudges) about educational benefits can be low-cost**<sup>228</sup> (Chile<sup>229</sup> and Peru<sup>230</sup>), but if resources to act on those changed beliefs are not provided, it may cause further anxiety. Aurino et al (2022, p. 9) studied a trial in Ghana that had produced mixed results. The study found that behavioral nudges on average “decreased caregiver engagement, decreased self-reported school enrollment and attendance, decreased caregiver mental health, and decreased children’s academic skills,” indicating that providing people with information without giving them the necessary means to act on it increases their stress. Similarly, Orozco-Olvera and Rascon-Ramirez (2022) on Nigeria found that videos to increase parental aspirations had no impact on learning outcomes alone, but when coupled with preloaded smartphones, it resulted in increases in literacy and numeracy scores of 0.57 and 0.79 LAYS per US\$100 respectively. Beam et al (2022) on Bangladesh showed coupling information with one-on-one phone calls was more costly at US\$4.48 per household, yet led to increased numeracy scores of 0.35 to 0.37 SD, whereas providing information alone cost US\$2.77 per household but only increased scores by 0.11 SD.

**Cost data on educational television broadcasting collected over the last three decades illustrate the cost-effectiveness of using this method to reach learners in rural areas.**<sup>231</sup> The total implementation costs for the Brazil Telecurso program was US\$26 per student,<sup>232</sup> for

the Indian adaptation of Sesame Street was around 16 cents per student,<sup>233</sup> and for Ubongo Kids in Tanzania was 1 cent per student (production only<sup>234</sup>). Program costs vary depending on whether the model includes group viewing with teachers, additional resources, and the quality of the content.<sup>235</sup>

**Reusing and adapting open educational resources (OER) to develop educational materials increases cost-efficiency, but aligning them with the curriculum and getting government approval still take time and effort.** The total cost savings from OER are difficult to quantify given they are designed to be reused and adapted, but cost-effectiveness is a key reason for using OER.<sup>236</sup> It provides educational materials to educators in basic education (for example, Open Up Resources: USA) and higher education, bringing contextualization, personalization, and creativity into their teaching at little cost.<sup>237</sup> OERs have also been reused in national, curriculum-aligned learning management systems such as Uganda’s.<sup>238</sup> However, in Kenya, local commercial publishers have resisted the government’s role as regulators and competitors in content production.<sup>239</sup> Adopting OER is not simple as governments have stringent vetting approval processes and curriculum and cultural alignment needs.<sup>240</sup> OER is being reused for TPD in different country contexts, for example, in Zambia’s OER4Schools project, the Leh Wi Lan project in Sierra Leone, and Ghana’s Transforming Teacher Education and Learning (T-TEL) project. EdTech products reuse OER. For example, Kolibri curates OER in its content management system, and Gooru reuses different OER in its learning pathways. OER has also reduced costs for students in higher education (for example, via open textbooks) and in basic education. For example, using Siyavula’s open textbooks saved the South African government as much as ZAR 1,200 million between 2011 and 2013.<sup>241</sup>

**Technology is used in structured pedagogy and school-based national TPD programs as a cost-effective solution to provide continuous, quality TPD for all teachers.** Building on evidence that infrequent teacher training workshops and cascade models have not been very effective or cost-effective,<sup>242</sup> LMICs are shifting to using continuous learning models for their national TPD programs through school-based communities of learning.<sup>243</sup> OER, digitalized materials, audiovisual resources, learning management system, and instant messaging platforms are key enablers of these models and help to make the model cost-effective.<sup>244</sup> While the impact of virtual coaching has been found to decrease over time,<sup>245</sup> early findings in Senegal show that tele-coaching is more cost-effective than in-person coaching (costing almost 83 percent less to achieve 0.1 standard deviation of improvement in how teachers guided individual student reading practice). However, in-person coaching was preferred and has been found to be more effective.<sup>246</sup>



### 3.2.5 Quality and Relevance of Education at Scale

In reviewing 234 causal education studies in LMICs, Evans and Yuan (2022) found that effect sizes were halved when education projects scaled up from under 500 participants to over 5,000 participants.<sup>247</sup> This indicates that efforts to scale up face many challenges including a lack of evidence-based designs, limited end user involvement, limited innovation funding, a focus on the product rather than the underlying problem, and a lack of a strategic approach from governments.<sup>248</sup> Scaling is a challenge in HICs, as Kraft et al (2018) demonstrated in their analysis of 60 studies where scaling reduced achievement effects by a third. Technology can either aggravate this by adding more complexity or alleviate it through smoother delivery depending on the nature of the intervention. Drawing on experiences of scaling up digital initiatives in Chile, China, Indonesia, and the US, the Omidyar Network (2019) developed a useful model for equitable scaling using demand-led EdTech supply through sustainable models, enabling infrastructure, education policy and strategy, and human capacity and multi-stakeholder collaboration to bring the vision to fruition.

**Evidence is growing on how to scale up education interventions effectively, but the evidence mostly draws on implementations done by teams outside of government.** Crawford, Hares, and Sandefur, (2022) reviewed eight highly effective Learning at Scale programs that predominantly focused on “structured pedagogy” or “teaching at the right level”: Tanzania, Ghana Learning, [Lecture Pour Tous](#) in Senegal, [NEI Plus](#) in Nigeria, the [Pakistan Reading Project](#) in Pakistan, Read India, SERI in India, and [Tusome](#) in Kenya.<sup>249</sup> These studies were implemented by nongovernmental organizations (NGOs) or contractors so they do not capture the full complexity of government-led interventions. The features contributing to effective scaling include: (i) cultivating political will; (ii) focusing on multilevel program implementation; (iii) setting out clear expectations and processes; (iv) ensuring buy-in from (government) education stakeholders; (v) co-designing the scale up with users; (vi) building on existing programs and technologies, (vii) integrating monitoring and accountability; (viii) providing teacher support; (ix) adapting to the different needs of teachers and learners; (x) budgeting for all of this.<sup>250</sup>

**Distance learning and the distribution of prerecorded and/or preloaded content are the oldest and most cost-effective ways to scale up education delivery and, when coupled with in-person support and interactive group activities, can yield significant learning gains.** The largest EdTech initiative to date is the government-led 2004 reform in China that disseminated video recordings

by high-quality teachers to more than 100 million rural students using satellite internet and/or CDs.<sup>251</sup> Students watched the videos together and then, led by a local novice teacher, completed workbooks and activities. A difference-in-difference study showed that this had long-term positive impacts, including students staying in school longer and improved learning and labor market outcomes. One factor contributing to its success was that compliance with government policy tends to be high in China.<sup>252</sup> A similar approach is used in the 50-year-old Mexican Telesecundaria model, where positive learning gains have also been observed.<sup>253</sup>

**Growing out of the distance learning and OER movement, MOOCs have become the dominant way of providing massively scaled content.** Over 20,000 open online courses from 950 universities are currently being offered to over 220 million students worldwide (excluding data from China<sup>254</sup>). Many platforms have been modified to freemium models that offer a basic version of the product for free while charging for micro degrees. MOOCs were initially critiqued for being unidirectional, but many now incorporate interactive components through discussion boards, quizzes, and peer assignment marking. MOOCs are notorious for their high attrition rates, with only 10 percent of enrolled students completing their courses.<sup>255</sup> However, they are now considered to be a drop-in model to which learners only come to acquire specific knowledge and then leave.<sup>256</sup> Critics of MOOCs designed and offered in the Global North claim that they promote only Western knowledge systems and colonial languages, lack cultural diversity, and serve wealthier, degree-bearing students.<sup>257</sup> In recent years, there has been an increase in MOOC providers from other regions with more inclusive demographic profiles as indicated by the large user bases of Swayam in India (over 30 million users) and XuetangX in China (with over 80 million users).

**More recently, digital personalized learning is reaching an increasingly large scale but without the necessary assessment tools and processes to precisely diagnose an individual's learning needs.** As a result, the personalized learning environment is often more customized than personalized<sup>258</sup>. Teaching at the Right Level is an approach to help children acquire basic skills devised by Pratham, an Indian NGO. It has been rigorously evaluated by over five randomized control trial (RCTs) involving 5 million children.<sup>259</sup> Lessons learned from these trials that could be applied to scaling up a similar program implemented by the government included the need to pilot and stress-test the intervention in different contexts, the need to use evidence to foster its acceptance by the government, and ensuring that government staff are making long-term plans for the program's large-scale implementation.<sup>260</sup> Another RCT study of a personalized technology-aided instruction

program for middle school students called Mindspark showed promising results for all students but particularly academically weaker students.<sup>261</sup> In Uruguay, PAM, an adaptive math platform, was rolled out as one of the government's recommended learning tools (via Plan Ceibal), hosting 100,000 curriculum-aligned exercises.<sup>262</sup> Almost 50 percent of learners in grades 3 to 6 produced learning improvements of 0.2 SD, with larger gains for those with lower socioeconomic status.<sup>263</sup> Malawi is among the first nations to scale up a government-owned digital personalized learning program countrywide to 3.5 million users in 5,770 public schools, which cost US\$6 to US\$8 per child per year.<sup>264</sup> The scaling approach incorporated teacher training, direct community involvement to reach out-of-school learners, implementation toolkits, and localized content.<sup>265</sup> However, these opportunities can also present significant risk to children and families both in terms of safety and privacy of their data and age appropriateness of digital personalized learning in the foundational years, that should be evaluated and mitigated against.

**While multi-country digital learning platforms can be both cost-effective and scalable, governments prefer to be responsible for the platform's content.** Since the COVID-19 pandemic, many multi-country learning hubs have emerged that provide digital resources with a shared backbone of infrastructure, such as the Eastern and Southern Africa regional learning hub (RLH).<sup>266</sup> The RLH plugs into the Learning Passport initiative, which is live in 27 countries and is in development in many more.<sup>267</sup> Learning Passport has been adopted by countries within the Europe and Central Asia region including Poland, Kazakhstan, the Kyrgyz Republic, Montenegro, Serbia, Tajikistan, Uzbekistan, Kosovo, and Ukraine.<sup>268</sup> It is a component of UNICEF's regional implementation plan, which supports platforms, content, teacher support, internet access, devices, and youth engagement.<sup>269</sup> A case study in Kosovo shows how Learning Passport was integrated into the preexisting national blended learning digital platform on Microsoft ([shkollat.org](http://shkollat.org)), to provide a one-stop shop for digitally enabled education.<sup>270</sup> Challenges in uptake remain due to a lack of connectivity and limited availability of devices as well as the absence of a long-term political and financial commitment from the government, which has changed three times since [shkollat.org](http://shkollat.org) was first implemented.<sup>271</sup>

**While a range of digital learning platforms emerged during the pandemic aiming to reach learners at scale, a significant number of them have not proved to be sustainable and/or effective.** Findings from UNICEF (2022) revealed that "one-third of nationally developed platforms have entirely shut down, are outdated, or no longer fully functional, limiting learning approaches to help schoolchildren recover their education." The report further

found that, despite half of the world being offline, 70 percent of platforms do not offer offline capabilities. These findings illustrate the many challenges involved in scaling up digital learning, particularly the lack of incremental development due to delivery pressures, the limited consideration given to targeting the needs of specific groups, and significant financing and capacity constraints in delivering high-quality, scaled-up digital solutions in education.

### 3.2.6 System Strengthening and Resilience

**One of the primary obstacles encountered in educational systems is the absence of transparency and accountability with respect to the distribution of resources, teachers, metrics for measuring progress in learning, quality assurance, and accountability measures.**<sup>272</sup> It can be hard to get the right information to the right people at the right time, even when the data is available. The COVID-19 pandemic demonstrated that having robust and up-to-date education data is crucial for developing effective strategies to mitigate learning losses.

**Real-time data collection, cloud storage, learning analytics, and dashboards can help adaptive management of education systems. These can provide teachers, school managers, and government officials appropriate information they require to make better decisions.** With the increasing trend towards decentralizing governance in many countries, the available technologies can help to improve how data is collected, analyzed, used, and stored. Various tools for real-time data collection have emerged in recent years that can track teaching and learning activities as well as educators' and learners' progress to inform future improvements of these tools.<sup>273</sup> If appropriately designed dashboards can be useful for sharing relevant data with different stakeholder groups (instead of overwhelming teachers with questions) and for providing them with the resources and support required to make improvements.<sup>274</sup> There is significant opportunity for using real time robust data systems for generating "evidence as a service."<sup>275</sup> as a cost-effective way of data collection, aggregation and analysis that contributes to causal evidence, such as experimental and quasi experimental evidence generation.

**Digital tools and processes are particularly useful for enhancing the resilience and transparency of EMIS in emergency contexts.** Some factors that can make these EMIS work better include improving education data policies, frameworks, and processes as well as lowering staff turnover, overcoming poor infrastructure and intermittent connectivity, coordinating stakeholders, reducing data fragmentation, duplication, and gaps, and increasing accountability, trust, and buy-in from data collectors.<sup>276</sup> These can all be done using digital tools, as has happened in several EMIS projects in Africa and the Middle East.<sup>277</sup>



In South Sudan, for example, teachers used an SMS-based system to record daily attendance, which was then sent to the South Sudan Schools Attendance Monitoring System (SSAMS), an online cloud-based platform. SSAMS can make progress reports and create dashboards for different people.<sup>278</sup> In Ethiopia, early efforts to use technology to improve the EMIS did not work because the computers and generators provided were not functional and capacity was adversely affected by staff turnovers.<sup>279</sup> The country then developed an EMIS Action Plan to upgrade to faster, more automated technologies that were less dependent on electricity and constant connectivity such as tablets and SMS.<sup>280</sup> A geographic information system (GIS) was also added to the EMIS to map schools and clusters to inform the allocation of resources and teachers.<sup>281</sup>

**Similarly, big data, learning analytics, and digital formative assessment tools can provide personalized, dynamic feedback on students' progress and predict when they will need early interventions.**<sup>282</sup> Although investing in learning analytics is becoming common in educational institutions, two systematic reviews have found their effectiveness to be inconclusive and have raised concerns about usefulness beyond the institution given that the analytics are specific to discipline and context.<sup>283</sup> Noting that aggregated data is necessary to make learning analytics more accurate, some countries such as Uruguay and Estonia have begun using learning analytics nationally.<sup>284</sup> However, simpler school-level formative assessment tools have been shown to improve learning outcomes<sup>285</sup> such as Tangerine's Teach and Coach offline tools, which are being used in the Tusome project in Kenya.<sup>286</sup> To address the siloed development of learning analytics and personalization algorithms, [EIDU](#) has been introduced, which is a content-agnostic, open-source, anonymized learning dataset that different products can use to train and develop personalization algorithms.<sup>287</sup>

**Using building blocks in the development of digitally enabled education platforms can be cost-effective and support interoperability and scalability, even across sectors.**<sup>288</sup> Digital building blocks are open-source, modular, interoperable pieces of code or software that can be (re) used to build or tailor platforms.<sup>289</sup> Building blocks provide a middle ground between developing bespoke platforms and buying off-the-shelf platforms. A system-wide building blocks approach decentralizes the development of solutions, allowing different ecosystem actors to plug in and integrate.<sup>290</sup> For example, DHIS2, developed for the health sector, has also been created for the education sector, connecting the health and education MISs on the same backbone architecture.

**Developing a National Digital Education Architecture (NDEAR, India) that is linked to whole-of-government**

**digital initiatives fosters innovation and supports the development of a digitally enabled education ecosystem.** Some countries such as India and Uruguay are taking national-level approaches to lay the foundations for digitalizing education ecosystems. The NDEAR in India was formed through senior-level stakeholder engagement. Uruguay followed a similar top-down approach, forming PLAN Ceibal and the Ceibal Center to expand the use of ICT and improve the quality of and increase access to education. However, the rapid expansion of digitalized education service delivery also poses potential risks that need to be addressed proactively. These will be reviewed in the next section.

### 3.3. Understanding Potential Risks and Possible Mitigation Strategies

The digital environment has become one of the most frequented spaces of daily life, blurring long-standing distinctions between school, work, and home and posing new risks for society. A critical factor in the evolving digital risk landscape involves increasingly using digital devices and technologies to enable education, knowledge acquisition, communication, recreation, social connection, and civic discourse. Digital service providers (DSPs) and platform companies, whose business models rely on sustained user engagement, play a vital role in this transformation. The digital risk landscape for education systems, applications, and data is particularly complex, multifaceted, and rapidly evolving.

This section will offer perspectives on the major digital risks affecting access, privacy, safety, and security of education services. It will also discuss important policy initiatives intended to mitigate digital risks and spotlight the relevance of including an integrated risk management approach in the digital transition of any education system.

#### 3.3.1 Digital Risks

**One of the foremost risks of digital transitions is increasing exclusion and worsening the digital divide.** The pandemic highlighted and heightened concerns that the rapid expansion of digitalized education service delivery has not been experienced equally, revealing a deep digital divide that has created dramatic inequalities in learning opportunities. The digital divide is not merely a risk related to digital access alone but is also affected by access, autonomy, digital skills, motivation, purpose of use, quality of use, and social and cultural resources. Van Dijk (2005) grouped these factors into three levels: (i) the material divide; (ii) the skills and usage divide; and (iii) the divide based on intended tangible outcomes, all driven by the users' attitudes and motivation. This nuanced view of the digital divide is important because, even in contexts

**Box 15. The Evolution of the Digital Divide**

- *The first digital divide:* The rich have technology, while the poor do not.
- *The second digital divide:* The rich have technology and the skills to use it effectively, while the poor have technology but lack the skills to use it effectively.
- *The third digital divide:* The rich have access to both technology and people to help them to use it, while the poor have access to only to technology.

Source: Trucano (2023).

where there is widespread access to, for example, the internet and devices, some population groups may face significant barriers in terms of skills, usage, and motivation. For example, countries and regions with large aging populations, a high number of NEETs, significant displaced populations due to conflict or increasing climate shocks, and/or considerable deficits in foundational skills among the population.

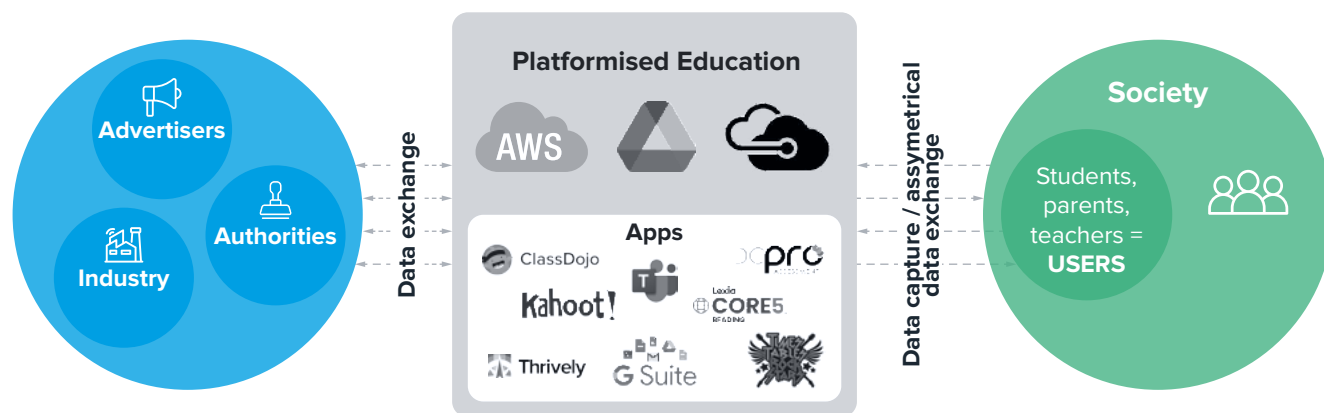
**In the age of AI, from an equity perspective, the rich may eventually have access to technology, digital skills, and human teachers, while the poor only have access to technology with limited skills to use it** (see [Box 15](#)). The digital divide has also heightened concerns about the “datafication” of personal student data (i.e. commercial use of personal data), the algorithmic reinforcement of discrimination against structurally disadvantaged groups, and the role of algorithmic processes in disseminating misinformation and disinformation, reinforcing the growing importance of media literacy. The pandemic made it clear that digital transformations are interconnected with broader systemic shifts such as geopolitical competition, political economy dynamics, and related inequalities and will continue to exert significant influence on human capital formation and a country’s growth trajectory.

**The risk of violations of data privacy and protection is increasing.** These privacy and surveillance risks (See

[Box 16](#) on Persuasive Design or Deceptive Design) arise not only from students’ personal information that they, their parents, or friends knowingly share (“data given”) but also from information gleaned from their online activities by data tracking technologies (“data traces”) as well as from data derived from algorithms (“inferred data”). Yet, the capacity of parents and teachers to effectively understand and supervise the digital activities of students is limited, with many lacking the critical digital literacy skills to protect against these risks.

**Merging public education with for-profit learning platforms, videoconferencing, and online proctoring services may pose severe risks to students’ privacy** ([Figure 10](#)). During COVID-19, most EdTech products were made available for no direct financial cost, allowing governments to offload the actual costs of online education onto students, who were unknowingly forced to pay for their access to learning with their rights to privacy, access to information, and potentially their freedom of thought.<sup>291</sup> Current consent models in school-based platforms often present a false choice, as opting out may exclude students from accessing learning opportunities. Laws should be enforced appropriately and regularly updated to ensure EdTech companies’ compliance with proper data privacy rights.<sup>292</sup> Parents, teachers, and school administrators should learn more about how EdTech companies use student data.<sup>293</sup>

**Figure 10. Education Platformization Poses Important Risks for Learners**



Source: Hillman (2024, forthcoming)<sup>294</sup>.

**Box 16. Persuasive Design or Deceptive Design**

Persuasive design is a form of user experience (UX) design that uses human psychology to design effective, fun, and engaging interactions. It is responsive to how we are as humans: how we think, react, and make decisions, leveraging common cognitive biases such as reciprocity, framing, and scarcity to spur decisions and actions, often in the digital world. For example, people like to have options when making a decision so persuasive design is used to frame those options in a way that guides them toward a “just right” choice or that indicates the scarcity of the product as people tend to be more decisive if they know something will not last much longer or that quantity is limited.

However, these persuasive designs can be deceptive. Digital apps, tools, and websites can employ tricks that make a person take actions that they did not mean to take, such as buying or signing up for something. This is a rapidly growing area of research, particularly in the fields of human-computer interaction (HCI) and law. Many types of deceptive patterns are already illegal in the EU and US, depending on the type and context of their use. In the EU, the Unfair Commercial Practices Directive (UCPD), the General Data Protection Regulation (GDPR), the Digital Services Act (DSA), and the Digital Markets Act (DMA) help to ensure a fairer internet for users. In the US, the Federal Trade Commission Act (FTC), the [Restore Online Shoppers' Confidence Act](#) (ROSCA), and [CAN-SPAM](#) are major federal laws that pack a punch. Despite these regulatory steps, [Deceptive.design](#) has collected over 400 examples of use of deceptive patterns in these and other regions in a hall of shame.

Sources: Authors' analysis.

**Students are also facing commercial risks due to fraudulent or misleading claims.** A recent review of 164 educational apps and websites across 49 countries found that nearly 90 percent of these tools were designed to pass information on to ad technology companies to target students' interests and influence their buying preferences.<sup>295</sup> Malware downloads and social networking apps open a backdoor to students' personal information being used for profiling, violating their fundamental legal rights and freedoms.<sup>296</sup> The maturity and age of the child may prevent them from comprehending the motivation behind this type of data collection or the longer-term privacy consequences. A few countries in the Organization for Economic Co-operation and Development (OECD) have adopted laws that specifically address consumer risks for school-age children.<sup>297</sup>

**Students also face risks to their online safety, health, and well-being.** In the digital environment, learners risk being exposed to digital content that can be: (i) hateful and motivated by the victim's religion, race, gender, disability, or sexual orientation; (ii) harmful such as online scams, pornography, or violent material; (iii) illegal to distribute under a country's laws and sociocultural norms; or (iv) meant to misrepresent news and information. Increased social media use contributes to poorer reading and shorter attention spans, so students are more vulnerable to believing fake news and may lack the knowledge to identify misleading information. Finland, ranked first in Europe on resilience against misinformation, is making a concerted effort to teach students about fake news. Starting in preschool, media literacy is part of the national core curriculum.<sup>298</sup>

**School-age children may also actively participate in or be exposed to conduct and contact risks through hateful or harmful encounters in the digital environment.** Cyberbullying can lead to negative consequences for the victim's personal development and safety. The exchange of sexual messages and images (known as “sexting”) is a growing practice among teens, with adverse implications for their privacy, health, and well-being and with potential criminal consequences.<sup>299</sup> This risk category also includes sexual exploitation and cyber grooming via email, chat rooms, and social media platforms.<sup>300</sup>

**The exposure to the digital environment for school-age children has raised widespread public concerns about the risks to health and well-being faced by youngsters.** There is growing interest in better understanding the effects of digital media use on brain function and structure as well as physical and mental health, education, social interaction, and politics.<sup>301</sup> Intensive digital media use has been implicated in reducing working memory capacity, causing psychological problems (from depression to anxiety and sleep disorders), and reducing the level of text comprehension while reading on screens. Higher use levels are associated with lower happiness levels, especially for girls. Heavy digital media multitaskers (MMT) are found to have poorer memory function, increased impulsivity, less empathy, and a higher amount of anxiety.<sup>302</sup> Early extensive screen use in preschoolers can have a dramatic negative influence on their language development neural networks, leading to speech delays. Cyberbullying can adversely affect the child's mental health, including raising their levels of depression, anxiety, and social exclusion.<sup>303</sup>

**The escalation of cyber threats and cybercrime puts critical infrastructure, social cohesion, and mental health at risk.**<sup>304</sup> Education institutions are prime targets for cyberattacks as they host a wealth of data, including personal information and sensitive research, and lack strong cybersecurity measures. Attacks on educational institutions are growing faster than in any other sector. A recent report found that 60 percent of all education institutions globally were targeted by ransomware attacks in 2021.<sup>305</sup> The attacks were largely successful, reducing their ability to operate. The report indicated that educational institutions suffered from the highest rate of data encryption (73 percent) compared to other sectors, paid the highest ransomware amounts, and took the longest time to recover their data. Digital service providers have also experienced damaging public relations fallout from cyberattacks (for example, Zoom bombing). Since it is almost impossible to protect fully against a cyberattack, having robust and defensible processes in place should help to protect against cyberattacks on critical infrastructure and data systems and trigger disaster recovery and business continuity plans in the event of a major incident. Legislative initiatives related to cyberattacks are beginning to take shape, with California becoming the first state in the United States to require K-12 schools to report any cyberattack affecting more than 500 students or personnel.<sup>306</sup>

**AI technologies promise benefits but can create inequalities, exclusion, discrimination, bias, and manipulation.**<sup>307</sup> Opening a backdoor to a “banality of surveillance” enabled by AI can inflict real harm. Students can be harmed by data breaches, privacy invasions, heightened test anxiety, unwarranted cheating flags, facial recognition bias, and expensive hardware requirements. Institutions can be harmed by a lack of compatibility with adaptive technologies, high costs of AI tools that are not fail-proof, violations of privacy laws, and liability exposure. And academic freedoms can be damaged by the erosion of student trust and the normalization of surveillance on students and faculty.<sup>308</sup> Teachers may also face increased stress and anxiety when using technology in teaching and learning.<sup>309</sup> See, for example, Trucano (2023).<sup>310</sup>

**While the purported benefits of AIED suggest a future of virtual teachers and personalized learning, significant risks to both learning and learners have not yet been addressed and many risks also remain unknown.**<sup>311</sup> See [Box 17](#) on Critical considerations for use of AIED. There is a risk that AIED systems will be deployed before the creation of sufficient ethical frameworks that use learning and human development as a starting point and explicitly consider issues such as fairness, accountability, transparency, bias, autonomy, agency, and inclusion.<sup>312</sup> New emotion recognition capabilities, for instance, can give an idea of who you are and provide information about students’ mental

state without their awareness and consent, prompting concerns about misclassification and stigmatization.<sup>313</sup> A second concern is that many AIED tools tend to drive the homogenization of students.<sup>314</sup> The risk is that the ability of teachers to personalize their teaching in response to each student may be replaced by so-called individual pathways that are based mostly on averages of prior learners while collaboration and other social interaction aspects of teaching and learning may be ignored, thereby replicating existing biases.<sup>315</sup> The OECD recommends that, unless appropriate measures are in place to protect children from harmful effects, digital platforms and applications should not allow the profiling of children.<sup>316</sup>

**Another important risk is the increasing commercialization of education, reflecting the interests of technology providers without addressing deeper social and cultural factors as these are difficult to change without broad stakeholder participation and policy change.** EdTech corporations increasingly sell their tools globally, creating asymmetries in power<sup>317</sup> by extracting local data from host countries, by drawing entire state education systems into adopting a narrow set of products across all institutions, and by imposing particular pedagogical approaches through digitalized tutoring systems. The widespread practice of unbundling (the process of disaggregating educational provision) and rebundling (the re-aggregation of those parts into new components and models) of education services may elevate the private good at the expense of the public good, creating an incoherent student experience, and lead to a monopolization of the education sector by a few companies.<sup>318</sup> Universities, EdTech companies, and investors have used market-led approaches to monetize different aspects of the education experience, including student support, credentials, networks, curriculum, learning pathways, resources, and academic expertise. A cautionary example is the replacement of free MOOCs with a freemium model, in which the lack of professional academic support for learners raises equity concerns, and casts doubt on education-for-all programs. New forms of credentials, such as micro-credentials and digital badges, which are central to the unbundling and rebundling of educational opportunities, have yet to demonstrate their value in the labor market. Another example of risk associated with the commercialization of EdTech is illustrated by the case of the multinational private company Byju’s, which has reached over 100 million students in 120 countries. It is alleged to have used coercive, unethical practices targeting the poor and disadvantaged to increase enrollments. Moreover, no rigorous evaluation was done to prove its efficacy,<sup>319</sup> and the company is now mired in extensive allegations of financial fraud, regulatory non-compliance and an indictment from the National Commission for the Protection of Child Rights in India due to its unethical practices.



**Box 17. Critical Considerations for Using AI in Education**

**AI solutions, platforms, and tools are revolutionizing education, offering diverse capabilities from problem-solving to language understanding and image analysis.** The integration of AI in education is evolving, and policymakers have yet to understand its impacts, especially in terms of ethics, equity, and data safety. The fast emergence of a wide range of free GenAI tools such as EduChat and MathGPT is fostering creativity by generating content across various domains, although critical evaluation is necessary to address potential biases. Alongside GenAI, AI's conversational abilities enable adaptive tutoring, feedback systems for writing, and customized learning experiences, particularly benefiting students with disabilities and English language learners. Furthermore, AI streamlines administrative tasks, such as drafting lesson plans and providing personalized recommendations for educators to meet diverse student needs. Adaptive platforms from educational technology leaders such as Carnegie Learning and Knewton offer real-time customization and assessment, while university chatbots and features such as Microsoft's Reading Coach and Assignments leverage AI to support learners and teachers by enhancing their reading skills and automating their grading processes respectively. Ethical considerations and collaboration between educational institutions and experts will be critical for maximizing AI's benefits while ensuring its responsible integration into education and addressing concerns about ethics, equity, and data safety in the educational landscape.

**The rapid technological developments in AI bring multiple risks and challenges.** The list of AI-infused specific technologies being used in education grows longer every day, introducing novel risks and challenges for students, teachers, and school leaders. Teachers may struggle with the technical expertise needed to integrate AI into their teaching practices. Schools face the obstacle of the costs of AI tools and applications and must grapple with ethical concerns around privacy and security. In higher education institutions, integrating AI raises additional risks, including data privacy issues regarding student information and the necessity for transparent data usage policies. Furthermore, equity and accessibility concerns arise due to potential digital divides and the varied needs of students, particularly those with disabilities. Moreover, there is a risk of over-reliance on large language models, which allow students to complete assignments with little effort, leaving no room to interpret and understand, thus diminishing critical human skills such as problem-solving and interpersonal communication if not appropriately balanced. Educational institutions must address these challenges to ensure responsible AI integration and maximize its benefits while safeguarding against potential risks in the evolving educational landscape.

**AI presents policymakers with complex challenges, including exacerbating digital inequality, biases, and obscure corporate practices.** Concerns raised in the education sector include plagiarism, reduced human connection, unknown psychological impacts, and stunted intellectual development. Considering these obstacles, UNESCO (2023) advocates a human-centric approach that entails the implementation of specific regulations on AI ethics and copyright laws, international or regional data protection regulations, and whole-of-government approaches. It will also be critical to build capacity for responsible AI use, implement regulatory frameworks, and monitor algorithms in order to promote innovation while also taking account of ethical considerations, human rights, and equity in education and research. Reflecting on the long-term implications of AI for education and research requires multisector stakeholders to engage in comprehensive discussions to ensure that a forward-thinking and ethically sound approach is taken to the integration of AI in education.

Source: Authors' analysis.

### 3.3.2 Risk Mitigation Initiatives

**The digital environment presents both opportunities and risks for students globally, which underscores the need for robust governance coalitions in each region and worldwide.** Clear guidelines and firm policy and compliance frameworks are needed to ensure equitable access for all students. Several guidance documents have been released to protect students' data and fundamental rights in educational settings, including by the Council of Europe,<sup>320</sup> the UN's International Telecommunication Union (ITU),<sup>321</sup> and the Global Privacy Assem-

bly.<sup>322</sup> The EU has been imposing significant regulatory fines on mishandling children's data and improper data transfers in breach of the GDPR, reaching US\$1.7 billion for Meta in 2022/2023 alone. OECD recently issued recommendations to find a balance between protecting children from risk and promoting the opportunities and benefits that the digital environment can provide.<sup>323</sup>

**Child rights impact assessments (CRIAs) have been adopted globally by countries in from Europe,<sup>xxxii,324</sup> Australia, and Canada, and, recently, in the Global South<sup>xxxiii,325</sup> in partnership with UNICEF.** The Coun-

xxxii Belgium, Bulgaria, Finland, Scotland, Spain, and Sweden.

xxxiii South Africa, India, Malaysia, Rwanda, Tanzania, Bolivia, Colombia, El Salvador, and Costa Rica.



cil of Europe's recent recommendation on the rights of the child in the digital environment<sup>326</sup> calls on states to "require business enterprises to perform regular child-rights risk assessments for digital technologies, products, services, and policies and to demonstrate that they are taking reasonable and proportionate measures to manage and mitigate such risks." To date, few global internet and mobile companies' practices meet minimum standards in the areas of privacy, freedom of expression, and remedy mechanisms for reported harms. However, there are some exceptions. For example, LEGO has pledged its compliance with the Children's Rights and Business Principles.<sup>327</sup>

**In another important step with significant implications for mental health, brain development, and social behavior affecting children, youths, and families, the European Parliament overwhelmingly called for action against the addictive design of apps, websites, and smartphones.** Addictive design features of online services, especially social media, such as endless scrolling, videos on autoplay, and default push notifications capture users' attention so they spend as much time as possible on platforms. The arguments tabled in [this European Parliamentary report](#) are significant and offer important lessons on potential risks and regulatory mitigation measures for LICs, LMICs, and MICs as connectivity, device access, and usage is becoming increasingly ubiquitous. The argument in favor of legislating in this area is that, while there are regulations for addictions such as drugs, alcohol, tobacco, or gambling, there have been none for addiction to digital platforms in general and social media in particular.

**While national and international support for digital risk mitigation initiatives is important and signals an emerging consensus, the interconnected nature of digital risks cuts across the entire education delivery system.** Managing and measuring the system's overall performance is the primary responsibility of educational leadership in government (at the federal, state, and local levels). How well is the entire system performing on strategy and operations in areas such as digital transition, user adoption, ecosystem dynamics, third-party networks? What risks are being disclosed? This calls for an integrated risk management approach that addresses four principal risk domains: (i) performance risks; (ii) resilience and continuity risks; (iii) compliance risks including those linked to violations of data privacy and cyberattacks; and (iv) risk assurance and monitoring. Central to this endeavor of risk mitigation is the role of evidence. Evaluations of EdTech products and evidence on the effectiveness of digitally enabled interventions in education are essential to determine where to invest the marginal dollar to improve outcomes. In the next section, we will delve into the broader question of where current research stands and what are the important considerations for the way forward.

### 3.4. Shaping the Future of Evidence

**The impact of technology use in education has been the subject of intense debate for several decades.** These debates raise a number of pertinent questions. Does it democratize learning for all or exacerbate inequalities? Does it compromise human skills and abilities or enhance them? Does it encourage excessive personalization/individualization at the cost of social interactions and conviviality? Should it be used to teach young children or is it a risk to their development? Are expensive short-run investments truly justifiable for delivering longer-run improved outcomes? Can the public interest and the commercial interest ever be compatible? These debates have been further fueled by the pandemic and the exponential global uptake of AI and large language model tools that offer unparalleled speed and increasing accuracy. In this context, there is a critical paucity of evidence not only on the learning impacts of technology but also on critical issues of equity, ethics, and fairness.

**Definitions and terminologies matter in how evidence is generated, interpreted, and used: Evidence on EdTech<sup>xxxiv</sup> is different from evidence on education interventions using digital solutions.** Evidence that an EdTech product or service works is different from evidence on education interventions that use EdTech or other digital solutions. The latter needs to establish whether the education process using the EdTech/digital product or service improves outcomes. Essentially, a distinction must be made between the evaluation of EdTech products that can inform market discovery and procurement decisions and the evaluation of an education intervention that uses digital solutions, including EdTech products and services. The latter should include impact and process evaluations as well as evaluations of implementation fidelity at scale. While it may be challenging to evaluate education interventions both with and without digital solutions as digital solutions become more embedded and ubiquitous in processes and practices, it is imperative to at least distinguish between efficacy (in a controlled environment) and effectiveness (at scale) of a given product or solution.

**With the advent of AI and the current sense of exuberance about technology use in education, the demand is starting to build for research evidence on technology use in education interventions.** The availability, affordability, and use of digital innovations in education (in formal, informal, and nonformal systems) have all grown rapidly in recent years. According to some estimates, the global education market is projected to reach US\$8 trillion in value by 2030, up from US\$6 trillion in 2022.<sup>328</sup> Worldwide investment in EdTech companies is on an upswing, with total investment growing from US\$9.56 billion in 2017 to

<sup>xxxiv</sup> EdTech refers to the private market and innovation ecosystem that develops commercial products, applications, and services for educational and skills development stakeholders. These can include, for example, B2C, B2G, B2B products and services. Whereas Education interventions using digital solutions refer to education policy, projects, and programmatic interventions that employ digital solutions as part of the intervention design and/or business process redesign. These digital solutions may or may not employ commercial EdTech products and services. What is important to note is that this places the education-related outcomes and related interaction processes at the center rather than the technology product/service at the center.

US\$25 billion in 2022.<sup>329</sup> Governments around the world accelerated their digital investments in education because of the pandemic and more recently because of advances in AI that promise to have long-reaching consequences on learning and labor markets. However, digital investments are often expensive, require adequate capacity for operations and maintenance, and often need upgrades, which can consume a large share of public education expenditures. Consequently, the need for robust research evidence is being felt much more strongly.<sup>330</sup>

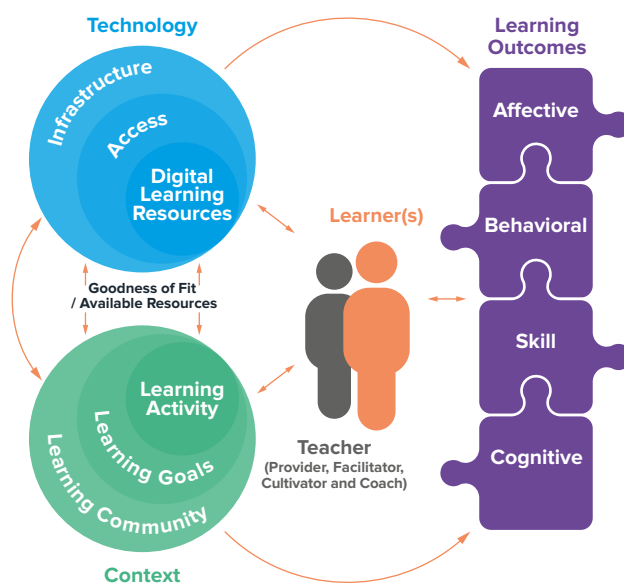
**With the fast-paced growth in the variety of EdTech solutions, tools, and platforms, it is challenging to identify quality.** Assessing quality requires the ability to know, for example, which digital solutions are based on the science of learning, their safety, the ease with which they can be connected with existing systems, their compliance with regulations and policies, their funding eligibility and costs, and their impact on users (students/teachers/others) in their context. Too often, policymakers and institutional managers must make rapid decisions about procurement or the in-house development of such solutions, tools, and platforms in an environment with a vast array of options. Without shared global standards of quality and relevant evidence, these decisions may be driven more by marketing and business metrics (such as user base, revenue, and margins) than by real impacts that technology can have on learning. Mislabeling digital products as educational or mislabeling the extent or quality of their features, functions, and capabilities can have serious negative ramifications, including exacerbating learning inequities at scale.

**There is a need for a shared set of global standards of quality assurance of digitally enabled educational products and services.** Due to the extensive information asymmetry between EdTech producers and education sector consumers, coupled with the extensive proliferation of products and services, there is no foolproof way to assess quality before purchase. This signifies a major risk that poor-quality products would drive out better-quality products (this is the classic “lemon problem” as outlined in George Akerlof’s 1970 paper on the effect of quality uncertainty on the market mechanism).<sup>331</sup> In the B2C segment of the market, for example, there were 455,000 apps advertised as “educational” in 2022, which was double the numbers that were available in 2014 (233,000 apps) in a largely unregulated and untested market.<sup>332</sup> Without any current standards for what qualifies as an educational app, there are only a handful of apps designed with an eye toward how children actually learn. Hirsch-Pasek et al (2015) found that only a small number of developers in either small start-ups or bigger toy or media companies have used research-based approaches with preliminary results of research.<sup>333</sup>

The digital transition in education includes a number of critical stages—from design to discovery to purchase decision to implementation and diffusion at scale—and research is lagging at all stages. Moreover, traditional measures of efficacy and effectiveness alone are not sufficient to judge whether a digitally enabled technology solution is appropriate for use in education as important questions related to quality, equity, ethics, security and safety, and user experience that must also be considered. There is a need for independent evaluation expertise with relevant knowledge and understanding for each stage.

- **Design of digitally enabled education products and services:** At this stage, research evidence based on the science of learning and user-centered design must come together with the users. The technology and learning contexts interact with the characteristics of the learner (Figure 11). Together, these shape the learner’s experience and the outcomes associated with their use of digital resources. This ecosystem is much more complex than the binary conceptions of technology use prevalent in the past.<sup>334</sup> Hence there is a need for educators, researchers, and app developers to be involved in the evidence-based design and production of digitally enabled education products.

**Figure 11. Technology and Learning Contexts Interact with the Characteristics of the Learner**



Source: Adapted from Darling-Hammond et al (2014). Reused with permission.

- **Market discovery:** At this stage, given the proliferation of solutions, research should not only evaluate the efficacy of EdTech products but also their results. Then the quality of these products from a technological, pedagogical, ethical, and financial standpoint should be cer-

**Figure 12. Understanding the ESSA\* Tiers of Evidence in Education**

	<b>TIER 1</b> <b>Strong evidence</b>	<b>TIER 2</b> <b>Moderate evidence</b>	<b>TIER 3</b> <b>Promising evidence</b>	<b>TIER 4</b> <b>Demonstrates a rationale</b>
<b>Study design</b>	Well-designed and implemented experimental study, meets WWC** standards without reservation	Well-designed and implemented quasi-experimental study meets WWC** standard with reservations	Well-designed and implemented correlational study, statistical controls for selection bias	Well-defined logic model based on rigorous research
<b>Results of the study</b>	Statistically significant positive effect on a relevant outcome	Statistically significant positive effect on a relevant outcome	Statistically significant positive effect on a relevant outcome	An effort to study the effects of the intervention is planned or currently under way
<b>Finding from related studies</b>	No strong negative finding from experimental or quasi-experimental studies	No strong negative finding from experimental or quasi-experimental studies	No strong negative finding from experimental or quasi-experimental studies	N/A
<b>Sample size and setting</b>	At least 350 participants, conducted in more than one district or school	At least 350 participants, conducted in more than one district or school	N/A	N/A
<b>Match</b>	Similar population and setting to your setting	Similar population and setting to your setting	N/A	N/A

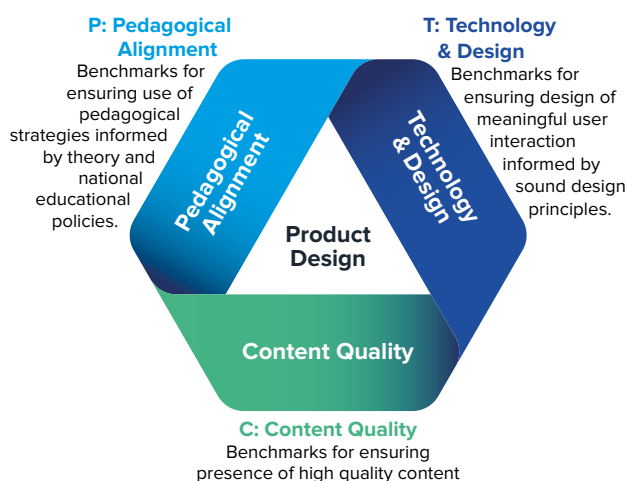
\*ESSA = Every Student Succeeds Act, \*\*WWC = What Works Clearinghouse, N/A = not applicable.

Source: REL Midwest. 2019. ESSA Tiers of Evidence What You Need to Know. Washington, DC: Regional Educational Laboratory at American Institutes for Research. <https://ies.ed.gov/ncee/edlabs/regions/midwest/pdf/blogs/RELMW-ESSA-Tiers-Video-Handout-508.pdf>.

tified using robust quality assurance mechanisms and standards. Some good examples of such robust quality assurance processes are the frameworks used by EdTech Impact, a UK company, and by [Instructure's](#) Evidence-as-a-service. Adopting tiered evidence-informed regulation and enforcement has proven to be useful in the US with its ESSA Standards of Evidence. To understand the value of the different types of efficacy measurements, the US Department of Education has defined four tiers of evidence as part of the Every Student Succeeds Act (ESSA) that encompass strong, moderate, promising, and rationale-based evidence that schools should look at before procuring EdTech products ([Figure 12](#)).<sup>335</sup> Each facet of the ESSA tiers is designed to indicate the level of confidence that school districts can have in the evidence. Chicago Public Schools include a question in their standard request for information from EdTech vendors asking them to show that their solution has an evidence base aligned with the ESSA standards. Similarly, the Los Angeles Unified School District requests its providers to show their evidence, along with data on and analysis of their solutions' impact.<sup>336</sup>

- **Purchase decisions:** At this stage, research evidence is required to evaluate a solution or product for public procurement. This often includes the potential procurer designing requests for procurement (RFPs) based on the problem to be solved ("ask why" in [Figure 13](#), Conceptual framework - strategic level) that ask for an in-depth evaluation of the product's contextual fit and for any market discovery insights of potential products or services. The procurer might also need a decision

support framework to compare the quality and costs factors in the selection of EdTech solutions that best fit their specific needs. These include aspects such as in-house development versus off the shelf purchase, cost-effectiveness, quality certifications, and procurement feasibility within regulatory frameworks among others. The [Edtech Tulna Framework](#) from India is a good example of such a framework that has been used for decision making ([Figure 13](#)). Furthermore, contextual evidence is also needed when designing an intervention, including social (for example, cultural norms), environmental (for example, rurality), political (for example, election cycles), and technological (for example, mobile penetration) factors.

**Figure 13. EdTech Tulna Framework**

- Early-stage implementation fidelity:** At this stage, intervention design must explicitly account for implementation factors (for example, logistical support, human capacity, training, and maintenance). Meta-analyses attempting to assess EdTech in isolation consistently raise concerns of confounding variables, where the EdTech treatment, coupled with non-technological changes in practice (sometimes spurred by the EdTech intervention itself), led to positive outcomes.<sup>337</sup> Implementation research evidence is essential for weeding out teething issues often using iterative and incremental user-feedback based design improvements in the real world. Research on implementation can identify bottlenecks and capacity constraints at various system levels (national, subnational, school levels) that prevent policies from achieving their full potential. These include methodologies such as action research,<sup>338</sup> rapid evaluation cycles,<sup>339</sup> design-based research (DBR),<sup>340</sup> design-based implementation research (DBIR),<sup>341</sup> problem driven iterative adaptation (PDIA),<sup>342</sup> and the sandbox model.<sup>343</sup> While these methodologies (aptly) recommend implementers to co-design and co-research their products with implementation partners or the government, these partners can bring their own biases and self-interest to the process so a concerted effort is needed to remain objective.<sup>344</sup> Early stage implementation need not be in a small scale pilot. In fact it might be prudent to begin with an eventual scale up in mind as scaling up small pilot digital interventions is fraught with challenges, can increase systemic fragmentation, and often prone to failure.<sup>xxxv,345,346</sup>
  - Impact evaluation of education interventions at scale:** At this stage, robust experimental evidence based on research methods<sup>xxxvi</sup> including RCTs and difference-in-difference methods are relevant.<sup>347</sup> Recent approaches such as the Multiphase Optimization Strategy (MOST) and Sequential Multiple Assigned Randomized Trials (SMART)<sup>348</sup> are important for determining the effectiveness of scaled-up adaptive education interventions<sup>xxxvii</sup> on outcomes of interest. Other statistical methods could be used<sup>xxxviii,349</sup> including computationally intensive approaches (such as geoinformation systems),<sup>350</sup> SMART,<sup>351</sup> and nimble randomized control trials.<sup>352</sup> Newer agile approaches to econometrics are using adaptive data collection for policy learning<sup>353</sup> and determining how experimental design can be used in staggered rollouts (accounting for lack of statistical power).<sup>354</sup> These methodologies can produce just-in-time findings in a cost-effective and timely manner. Finally, when considering scaling, holistic designs, such as systematic mixed methods research (SMMR), can meet the need for formative, fast feedback loops and larger-scale, longer-term rigor due to the fast-evolving nature of EdTech and its potential for large-scale impact and reach.<sup>355</sup>
  - Process evaluations of education interventions:** It is important to evaluate the effectiveness of the digitally enabled intervention from a technological, pedagogical, ethical, and financial standpoint to inform future designs. The research evidence should help to answer “What additional affordances do EdTech components add to education interventions in their specific context to improve outcomes? And is this value-add more cost-effective than a non-technology enabled intervention?”<sup>356</sup> A systemic approach is particularly useful to measure the complexity of interventions that include EdTech, especially in light of research that demonstrates the sensitivity of outcomes to implementation choices.<sup>357</sup> Examples of systemic frameworks include the EdTech-specific 6Ps of the education system framework (People, Practices, Places, Provision, Products, and Policies)<sup>358</sup> or tech-supported structured pedagogy that maps how technology can support across the different components of structured pedagogy (Leadership Development, Lesson Guides, Teaching Materials, Learning Materials, Teacher Training, Ongoing Teacher Support, Assessment and System Management).<sup>359</sup> Sometimes more tailored methodologies are needed to achieve unique purposes. If trying to unpack system changes to measure system effectiveness, outcome harvesting,<sup>360</sup> network analysis,<sup>361</sup> techniques associated with adaptive management,<sup>362</sup> and political ethnography or political economy analysis<sup>363</sup> may be more useful. Drawing on implementation science,<sup>364</sup> a whole system approach is useful to analyze complexity within interventions that leverage EdTech, especially as research demonstrates the sensitivity of outcomes to implementation choices, particularly when scaled.<sup>365</sup>
- Given the various reasons for seeking evidence, methodological plurality must become the cornerstone of research on education interventions involving digital solutions.** There is increasing recognition among investors, governments, and product developers of the inherent difficulties involved in measuring the efficacy of technology use in education, which often requires resource-intensive research projects that currently operate in the absence of any mutually agreed global metrics. As noted earlier, different research methodologies are applicable to different stages of the digital innovation, adoption, and scale-up cycle to generate relevant evidence. The key is to promote an innovation ecosystem that is driven by evidence-based quality standards as well as opportunities for fair selection, design improvements, and programmatic evaluations. Kucirkova et al (2023) propose a general EdTech EVER framework to conduct the quality assurance of digitally enabled education products, potentially drawing on the ESSA Standards of Evidence in the US or the Standards of Evidence in Australia, both of which embrace methodological plurality.

<sup>xxxv</sup> The *Principles of Digital Development* (n.d.) tackle the issue of ‘pilotitis’ and emphasize beginning with scale in mind through making initial cost-effective, contextualized, consultative design choices that will support widespread uptake. Scaling limitations include a lack of evidence-based designs, limited end user involvement, limited innovation funding, a focus on the product or the tech as opposed to the problem, and a lack of a strategic approach to EdTech from governments (Simpson et al. 2021).

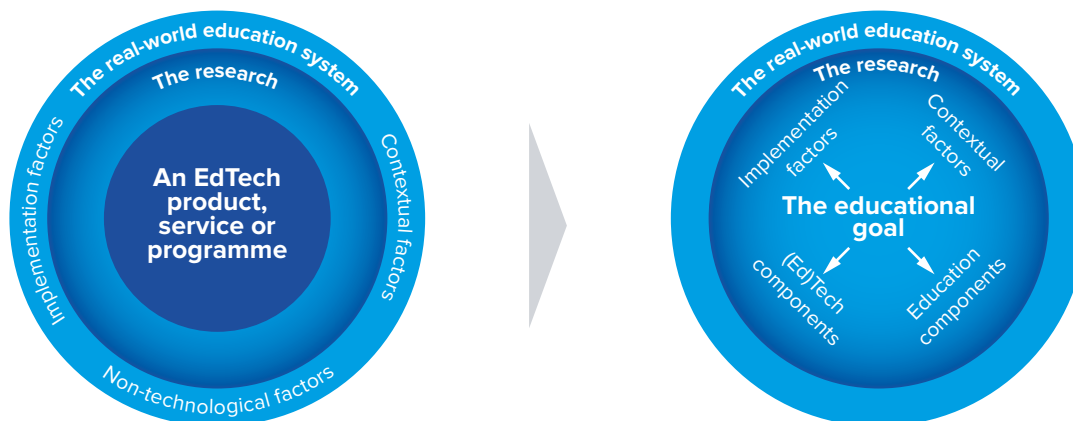
<sup>xxxvi</sup> In this era of the near ubiquitous use of technology in teaching, the comparison of a ‘technology-present treatment group’ with a ‘no-technology control group’ as a research question is less relevant, and in many cases, not feasible.

<sup>xxxvii</sup> In an adaptive intervention, the practitioner (or some other entity) modifies the dosage (duration, frequency, or amount), type, or delivery mode of an intervention to meet the unique and changing needs of individuals (or organizations). SMART involves multiple stages of randomizations, meaning that some or all individuals (or organizations) participating in a SMART are randomized more than once.

<sup>xxxviii</sup> See Haßler et al. 2021 for more details on diverse methodologies.



**Figure 14. Evaluating Educational Programs Leveraging EdTech**



**Research on an EdTech intervention:** "Does the EdTech offering improve learning outcomes?"

**Research on digitally-enabled education interventions:** "What additional affordances does EdTech add to the education intervention?"

- Is the research being conducted with or informed by long-term owners (e.g. the government) and stakeholders (e.g. teachers)?
- Who is implementing the intervention? e.g. external experts, local NGOs, government, teachers, or volunteers
- When is the intervention taking place? e.g. election years, census data collection, exam time in schools, religious festivals
- How is it being implemented? e.g. dosage, blended, after school
- What are the prerequisites for the intervention to work? e.g. electricity, connectivity, devices, support staff
- What are technological components of the intervention? e.g. radio or augmented reality
- What is the environment? e.g. country, rurality, rainy area
- What is the educational purpose? e.g. literacy programme, TPD

There is an urgent need for policymakers to create a more conducive regulatory environment for promoting and supporting the development of high-quality learning-centered products and services. Policymakers are often required to make procurement and investment decisions fairly quickly in a fiscally constrained environment and with limited evidence. Yet these investments are often large and come with significant opportunity costs, especially in LICs and LMICs. Hence, governments can play a more proactive role in demanding evidence that can enhance decision-making and reduce investment risks. Given the accelerating scale and speed of these investments, this research must be fast, cost-effective, and scalable. Policymakers can take an approach of *well-informed and qualified optimism* for allocating marginal investment dollars in digital solutions in education. They can seek evidence that answers the following questions: What purpose does this serve? How can we know that this is working? How effective will this investment be in improving outcomes in my context? Why is this particular digital solution better than alternative analog or other digital solutions? They can play an even more active role by requiring clear and concrete evidence at various stages of

the innovation-adoption-scale-up cycle to inform decision-making, and publicly procure well proven products.

**For evidence to be useful, a nuanced and deep understanding of various contextual factors is needed.** This can include the availability of suitable infrastructure and conducive legal and policy frameworks for the deployment of promising EdTech products, adequate funding allocations for their operation and maintenance, the alignment with national curriculum standards, the proficiency of educators in using the technology effectively, and the presence of supportive home and community environments conducive to learning.

**The next chapter** will explore the contextual conditions needed to enable education systems to make the digital transition. This will include a discussion of frameworks, methods, and tools for assessing the current state of play of a country's education system and technological readiness and for determining appropriate courses of action.<sup>366</sup>



# 4 CONTEXTUAL CONDITIONS FOR UNLOCKING THE POWER OF DIGITAL IN EDUCATION SYSTEMS

**Various contextual conditions at the country and sector levels need to be in place for individuals, communities, and societies to realize the potential benefits of incorporating digital solutions to improve education outcomes.**

The state of readiness of these contextual conditions has predictive power, especially during periods of heightened uncertainty. A recent report by the Broadband Commission on the potential for hybrid learning<sup>367</sup> highlighted the importance of assessing a country's digital maturity level to help governments and organizations to determine its ability to effectively manage and guide digital transformation efforts. This would also enable policymakers to consider various possible scenarios and incorporate relevant international good practices and experiences into their plans to ensure that policies in place today remain resilient to future shocks, including climate change, conflict, and fragility.

**When a country is planning to undertake a digital transformation in support of an equitable, fit-for-purpose, and resilient education system, it must prioritize equity and rights.** Going digital in education can be achieved via different pathways depending on the country's needs and context. The digital maturity of an economy (and, by extension, the maturity of its various sectors) is highly correlated with per capita income as the more mature and diversified an economy or ecosystem is, the more likely it is to have the necessary infrastructure, institutions, regulations, and human capital already in place.<sup>368</sup> This means that public investments must be centered around the needs, readiness, and potential benefits for those with the least power (such as children, young people, women, people with disabilities, minority groups, and marginalized communities).

## 4.1 Digital Readiness of the Education System: The Five Pillars

**The contextual conditions required for education systems to be ready to benefit from a digital transition revolve around five essential pillars.** These are: (i) strategic leadership and governance capable of delivering human-centered services; (ii) a robust data and technology infrastructure; (iii) digitally enabled delivery and analytics of education services and school digital maturity; (iv) the capacity and culture of the education workforce; and (v) the EdTech market and business models. Each of these pillars plays a crucial role in shaping the digital pathways

of any country and in providing a comprehensive framework for informed decision-making. These contextual conditions collectively serve as a foundation for the digital transition of a country's education system.<sup>369</sup>

### 4.1.1 Strategic Leadership and Governance

*This pillar aligns with the Strategic Layer of the conceptual framework.*

**Government policies, strategies, regulations, and commitment to digitally enabled education are significant determinants of digital readiness.** These help to promote the safe, ethical, and equitable use of digital technologies in education.<sup>370</sup> Governments must come up with a clear vision and strategy for digitally enabled education systems. This should be supported by durable legislation and equitable financing. However, it is crucial to recognize that the benefits of strategic leadership and governance depend on meeting certain preconditions, such as adequate and sustainable financing and procurement mechanisms. If these preconditions are not met, the advantages will not accrue automatically. Adequate and sustainable financing and procurement mechanisms are necessary to incentivize schools and teachers to adopt and scale up technology-enabled solutions to deliver education services.

**Many LICs, LMICs, and UMICs face challenges in trying to digitally enable their education systems, particularly in terms of collaborative leadership, the alignment of policies and action plans, and the mobilization of adequate financing.**<sup>371</sup> Addressing these challenges requires the existence of champions of digital transformation in the different levels of government, the strengthening of institutional capacity, and the setting of performance standards for critical business processes to establish accountability. This requires that:

- Crucial areas for change management support are identified.
- Regulatory structures beyond the Ministry of Education coalesce to ensure the safety and security of digital users.
- Links are established between educational digital solutions and national digital infrastructure, such as the Cloud, and digital government services.
- The education and skills development sector has the required political capital to enable change.

For example, Norway has an integrated approach to digital education policy that is incorporated into its broader education strategy. The Norwegian Directorate for Education and Training oversees the digital competence of all students, apprentices, and teachers.<sup>372</sup> Also, the Finnish Ministry of Education and Culture recently published [Policies for the digitalisation of education and training until 2027](#), which outlines the measures and responsibilities needed to realize these three aspirations: (i) everyone's ability to

learn and develop their competence is improved through digitalization; (ii) digital solutions constitute a high-quality, interoperable digital operating environment that supports cooperation between actors; and (iii) digitalization supports knowledge-based development. These aspirations are embedded in the Finnish vision to be the world's leading developer and user of sustainable digitalization in education, teaching, and training by 2027.

#### Box 18. EU's New Landmark AI Law

**The EU's new AI law that was adopted in March 2024 will have implications for human development objectives and outcomes in the region and beyond.** While it remains to be seen how the new law will be enforced, implemented, and updated in a fast-changing digital and AI landscape, the law itself introduces important binding rules on AI applications and uses, enshrining the principles of “safety, fundamental rights and democracy, while enabling businesses to thrive and expand.” The law is not being applied in isolation and will be complementary to two related regulations, the Digital Services Act and the Digital Markets Act, that establish a complex transparency and data-access regime governing AI technologies in the EU.

**The EU AI Act is being recognized as the world's first AI law with the necessary teeth to regulate AI based on its capacity to cause harm.** It includes binding rules on transparency, accountability, and respect for fundamental human rights. Two and a half years after the bill was first introduced, EU lawmakers reached a political deal over what has become a global benchmark on regulating AI. The biggest challenge facing lawmakers was how deeply to regulate AI to safeguard the rights and freedoms of individuals without handicapping European start-ups and small and medium enterprises (SMEs). The law is a landmark in the sense that it is intended to be legally binding (going beyond the voluntary commitments made by tech companies in the US) and includes blanket bans, few exceptions, several obligations, guardrails, and monetary sanctions. It includes initial steps for the Act's implementation, compliance, and enforcement as well as steep fines for non-compliance (ranging from EUR 35 million or 7 percent of global turnover to EUR 7.5 million or 1.5 percent of turnover, depending on the infringement and size of the company).

**The landmark bill aims to mitigate harm in areas where using AI poses an “unacceptable” risk to fundamental rights, such as health care, education, border surveillance, and public services.** It completely prohibits the use of AI for biometric categorization systems that use sensitive characteristics (for example, political, religious, philosophical beliefs, sexual orientation, or race), untargeted scraping of facial images from the internet or CCTV footage to create facial recognition databases such as Clearview AI, emotion recognition in the workplace and educational institutions, [social scoring](#) based on social behavior or personal characteristics, AI systems that manipulate human behavior to circumvent their free will, and AI that is used to exploit people's vulnerabilities (due to their age, disability, social, or economic situation). [Predictive policing](#) may only be used under strict rules such as clear human assessment and objective facts, not only algorithmic decision-making.

**The AI law applies more stringent compliance rules in terms of risk management and data governance for AI systems, models, and applications with greater computational power as they pose greater risks.** “High risk” AI systems and foundational AI models will have to adhere to strict rules that require them to implement risk mitigation systems, maintain high-quality data sets, comply with EU copyright law, keep better documentation, meet future-proof technical standards (including environmental standards) and ensure human oversight, for example. How best to assess the computational power of evolving AI models and who will do the assessments is unclear, as AI models are often not open source. Tech companies will have to notify people when they interact with a chatbot with a biometric categorization or emotion recognition systems. They are required to label deepfakes and AI-generated content and design systems in such a way that AI-generated media can be detected. The vast majority of AI uses, such as recommender systems and spam filters, will broadly not be restricted. The law aims to help SMEs to develop innovative AI solutions without undue pressure from dominant industry giants by promoting regulatory “sandboxes” and real-world testing under the oversight of national authorities.

Sources: [European Parliament](#), [Euractiv](#), [MIT Tech Review](#), [Atlantic Council](#), [New York Times](#).

## 4.1.2 Data and Technology Infrastructure and Management

*This pillar aligns with the Partnerships Layer and the Education ICT and Data Layer of the conceptual framework.*

**Infrastructure is the backbone of any educational system, providing the essential foundation for effective teaching, learning, and administrative processes, particularly in the context of the digital evolution of education.** Effectively managed infrastructure enables access to knowledge and opportunities regardless of location or socioeconomic status. A reliable infrastructure, including physical facilities, electricity, connectivity, and technological resources, is essential for fostering innovation, efficiency, and equitable access to education. A well-developed physical and digital infrastructure empowers the learning environment allowing educators to employ diverse teaching methods, utilize digital tools, and make informed decisions through data analysis.

**The availability and adequacy of electricity, telecommunications infrastructure including equipment and digital devices, and meaningful internet connectivity are essential part of the ICT backbone.** Once these foundational infrastructural barriers are overcome, it is necessary to ensure access to high-speed internet in schools, to devices for use by teachers and students, and to appropriate software and learning platforms.<sup>373</sup> For example, the national government in Korea has consistently invested in nationwide high-speed broadband infrastructure, leading to wider access to digital education resources. Similarly, after the Danish government invested in broadband infrastructure, over 97 percent of households now have internet access.<sup>374</sup> These significant investments have successfully allowed Danish schools to integrate digital learning into their curricula. In contrast, the internet penetration rate in Chad is less than 5 percent,<sup>375</sup> making the implementation of digitally enabled learning solutions much more difficult.

**Developing the architecture of a digitally enabled education system is essential, consisting of a coherent, integrated blueprint that aligns people, data, and technology.** This includes the variety of devices, operating systems, tech stacks, protocols, metadata, standards, workflows, applications, and networking equipment that can empower the service delivery and analytics space needed for learning. Effective data governance is crucial for maintaining data privacy, security, and ethics in a digitally enabled education system. In addition, interoperability—the ability of different information systems, devices, and applications to access, exchange, integrate, and cooperatively use data in a coordinated manner—is vital for efficient and seamless digital learning experiences.<sup>376</sup> In 2012, the

European Commission established [CLARIN](#), an open and distributed digital infrastructure that offers an interoperable language technology platform for multidisciplinary research to advance digital linguistics. The EU's General Data Protection Regulation (GDPR) provides a framework for data governance in digitally enabled education, balancing the need for data to improve learning with the need to protect personal data.<sup>377</sup> To address interoperability, the US Department of Education has developed the [Ed-Fi Data Standard and Technology Suite](#), which provides a set of rules for collecting, managing, and organizing education data to enable seamless exchange between systems. More recently, there are significant efforts globally to regulate Artificial Intelligence applications including in education. See [Box 18](#) for EU's landmark AI Act.

## 4.1.3 Digitally Enabled Education Service Delivery and School Digital Maturity

*This pillar aligns with the Education ICT and Data Layer and the Implementation Layer of the conceptual framework.*

**Service delivery is at the heart of the education process and is the key to unlocking the benefits of going digital.** Depending on the extent to which digital solutions are embedded in education service delivery, they can enable personalization of learning, dynamic responses to the students' and teachers' learning and teaching needs, and better management and analytics to augment decision-making. The focus here is on teacher-learner interactions, the instructional leadership of administrators and school managers, and the strengthening of the curriculum, teaching and learning materials, assessments, analytics, and institutional management, including at the school, local, and regional levels. Teachers need to be trained in the necessary competences (skills, knowledge, and attitudes) to integrate technology into their teaching methods as well as into their curricular content to enhance learning outcomes. With reference to the SAMR (Substitution, Augmentation, Modification and Redefinition) model xxvii, which describes how technology can be applied to teaching and learning, this goes beyond substituting traditional teaching methods with digital ones into more advanced uses such as the augmentation, modification, and redefinition of learning. It will also be essential to implement robust and systematic assessment of the digital competences of students.

**Providing high-quality, localized digital content in the languages spoken and understood by learners is crucial for effective teaching and learning.** Many LICs, MICs, and also HICs lack digital content and devices that are culturally and linguistically diverse. This makes it impossible for non-English-speaking learners to use digital content as effectively as their English-speaking peers. Moreover, AI

and adaptive learning systems rely on codified, contextualized knowledge in the form of large training data sets, but these remain underdeveloped in many languages across all regions. The EU continues to invest in the agenda of language diversity in the digital age as recommended in the EU report [Language equality in the digital age - Towards a Human Language Project](#) commissioned by the European Parliament in 2017. Lenovo recently launched a New Zealand bilingual keyboard designed to seamlessly write in the indigenous language, te reo Māori. This initiative was driven by a student who had begun to learn te reo Māori in school and questioned why there was no hardware available to support his learning.<sup>378</sup> Canada has focused on creating digital content in both English and French, reflecting its bilingual policy and the diversity of cultural backgrounds among its population.<sup>379</sup>

**Multidisciplinary expertise is required to objectively assess the quality, cost-effectiveness, and risks of using digital products and services in educational settings.** Too often, educators, administrators, and institutional managers have to make complex decisions on the procurement and/or in-house development of digital tools, solutions and platforms. Yet choosing between the growing plethora of digital solutions, tools, and platforms that are labelled as “educational” can be overwhelming. An understanding of different technological tools, educational needs, pedagogical knowhow, and contextual awareness are often needed to weigh the merits and risks appropriately. Responding to this need, several entities—such as Education Alliance Finland, LearnPlatform USA (Instructure), EdTech Evidence Exchange, India’s EdTech Tulna, and [Goldstar Education](#), among others— have been established to provide schools and governments with evidence-based infor-

mation to help them make better informed procurement decisions about digital products and services in education with relevant quality standards that will serve the learner and learning (see [Box 19](#)).

#### 4.1.4 Education Workforce Capacity and Culture

*This pillar refers to the human resource capacity for designing and implementing policies and practices to support the development of a digitally enabled education system. This applies across the whole conceptual framework (the depth of digital transitions).*

**Enhancing the skills, capacity and collaboration across a wide range of stakeholders is required to support the development of a digitally enabled education system.**

There is a need for widespread knowledge of digital area and upskilling of the workforce with digital competences, including for policymakers, bureaucrats, administrators, and teaching staff. Multidisciplinary teams with specialization in ICT and educational fields are required to make well-informed decisions. There is also a need for technical support staff to facilitate the integration of digital technologies in education in schools. Policymakers need to foster a culture that focuses on the user needs, develops a positive attitude towards digitalization, encourages innovation, incentivizes skills development and collaboration, aims to increase trust in governance and data, and takes an evidence-based approach to managing change and disruption. In Finland, for example, a culture of trust in potential use of technology, a strong belief in equity in education, and active parental involvement are integration of digital learning into education.<sup>380</sup>

#### **Box 19. EdTech Tulna - Navigating the Complex EdTech Landscape (India)**

**EdTech Tulna provides an evaluation framework and standards to enable decision-makers and individual users in India to make an unbiased quality assessment of EdTech solutions.** Tulna means comparative measurement in the Hindi language. [EdTech Tulna](#) offers three main services: (i) standards and quality frameworks; (ii) toolkits for making effective procurement decisions; and (iii) independent expert reviews of existing products. The company takes a research-based approach to creating frameworks that are sensitive to the local context and globally relevant. Based on global research literature, government policy documents, and stakeholder interviews, it emphasizes the mechanism of how and why a product is effective in the Indian context. EdTech Tulna’s standards have three dimensions: (i) Content Quality: the quality of educational content with regard to accuracy, coverage of national standards, appropriateness for targeted grade and learners, and language comprehensibility; (ii) Pedagogical Alignment: alignment of EdTech solutions with national educational policy on pedagogy and assessments; and (iii) Technology and Design: how technological affordances integrate with pedagogy and content.

**The State governments of Haryana and Madhya Pradesh in India have used EdTech Tulna as the technical evaluation framework for the official process of comparing and selecting a proposal to procure Personalized Adaptive Learning (PAL) solutions for schools.** EdTech Tulna has offered frameworks and evaluations catering to three key use cases for mathematics (in grades pre-K to 10): Personalized Adaptive Learning (PAL), Digital Classrooms (DCRs), and Interactive Audio Visual (Interactive AVs).

Source: Authors’ compilation.



**The digital skills of the education workforce and public education administrators are crucial for effective digital learning.**<sup>381</sup> Teachers need to be digitally literate to integrate technology into their lessons, while public education administrators at both the school and system levels need digital skills to understand and make informed decisions about digital learning technologies.<sup>382</sup> In India, the government has implemented the [Diksha platform](#), an initiative to train teachers in digital pedagogies, and NGOs such as Pratham have recognized the gap in digital skills and are running digital literacy programs for students and teachers. Several OECD countries have professional development programs to enhance teachers' digital competencies such as Austria, Korea, France, Spain.<sup>383</sup> However, there is still a pressing need for teacher training in digital skills in many LMICs and LICs. Socioeconomic inequalities, parental involvement, and cultural attitudes toward technology also influence the digital readiness of the education workforce.<sup>384</sup> **Educators' working conditions, career structures and professional support can facilitate or constrain their ability to make effective use of digital education technologies.** Although the use of digital education technologies may make some aspects of teachers' work more efficient and given them access to an abundance of learning resources, navigating these resources, preparing digitally enhanced lessons and learning how to do so effectively takes time<sup>385</sup>. Teachers' working time arrangements, incentives and career reward structures and opportunities for professional development must support digital pedagogy. In this, school leadership teams, in addition to education governance, play a central role in preparing teachers for the successful integration of digital education technologies. They are critical to ensure that teachers remain motivated to engage in professional growth, to appraise teachers and link their individual learning with the school's overall priorities and strategies for the adoption of digital technologies. Decisions on the management of staff time shape teachers' opportunities to engage in collaborative practices and other forms of peer learning that are critical to build school level capacity for the successful adoption of education technology<sup>386</sup>.

#### 4.1.5 EdTech Market and Business Models

*This pillar refers to the maturity of the private market and innovation ecosystem, which cuts across the whole conceptual framework (the scale of the digital transition).*

**The EdTech market solutions comprise a network of technologies, platforms, and services aimed at enhancing teaching and learning experiences.** It involves stakeholders such as educators, students, EdTech innovation ecosystem, policymakers, institutions, and investors. Collaboration among these parties is crucial for the ecosystem's growth and sustainability. The ecosystem aims to

support educational processes, improve learning access, and foster innovative teaching methods. Leadership and governance play key roles in shaping a conducive environment for EdTech innovation. Private sector participation, supportive policies, and financing for research and implementation are essential components. Additionally, digital infrastructure and the digital competencies of staff and students are vital for successful EdTech adoption and effective learning with technology.

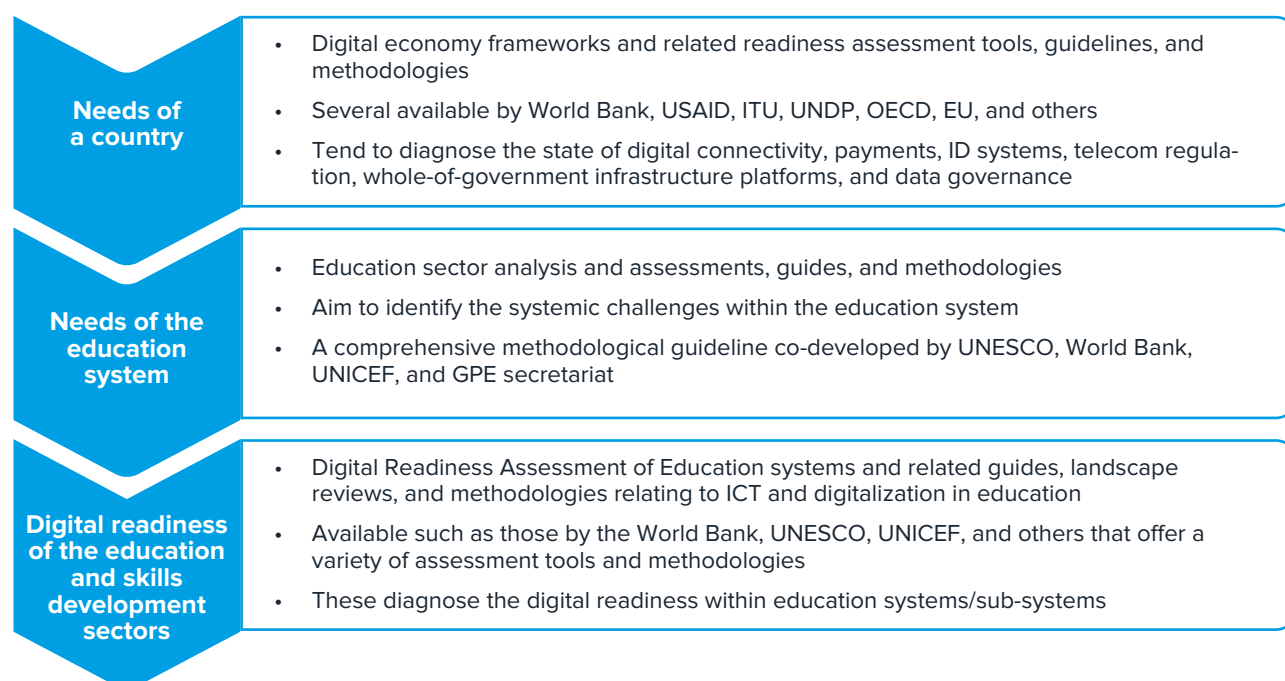
**Effective innovation ecosystems foster close collaboration amongst universities, research institutions, start-ups, and private enterprises to enable the digital transitions in education.** They contribute to the development of new digital learning tools, models, and strategies and foster a culture of innovation and entrepreneurship that helps to drive the digital transformation of education.<sup>387</sup> For example, EdTech hubs in Kenya, such as iHub and Nailab, foster digital education innovations by supporting start-ups that come up with solutions to local educational challenges.<sup>388</sup> Public-private partnerships (PPPs), where feasible, can be useful for bridging resource gaps.<sup>389</sup> In Colombia, the Ministry of Education partnered with several tech companies to donate computers to implement its Computers to Educate program (*Computadores para Educar*), which increased the availability of devices in schools and improved the acceptance rate of high school students in higher education.<sup>390</sup>

**High quality innovation and equitable distribution of Edtech requires access to capital markets, supportive legislation, and viable business models that can leverage digital global value chains**<sup>391</sup>. Innovative business models could be sustained in a variety of ways, including through direct consumer purchasing power, government procurement or grant programs, private investment, or some combination thereof.<sup>392</sup> By enabling financing options, fostering competition and setting standards for quality and equity, policymakers can play a proactive role in germinating an edtech innovation ecosystem that supports education policy priorities and goals. At the same time, it is necessary to enforce regulations that strengthen the selection and procurement processes for high quality EdTech products and services that objectively match identified education needs.

## 4.2 Digital Readiness Assessment Frameworks, Methods, and Tools

**Conducting a thorough diagnosis of the existing context is essential for policymakers to understand the needs and challenges of a country's education system and to develop a strategic roadmap for the digital transition in education** ([Figure 15](#)). The diagnosis should be based on three interconnected elements: (i) the needs of the coun-



**Figure 15. Assessment Frameworks and Tools for Diagnosing Education Needs and Related Digital Readiness**

Source: Author's analysis.

try; (ii) the needs of its education and skills development system; and (iii) the digital readiness of its education and skills development system. The diagnosis should first explore the socioeconomic goals and education priorities of the country along with the economy-wide state of the digital foundations (including connectivity, payments, ID systems, telecom regulation, whole-of-government infrastructure platforms, and data governance). As for the needs and challenges of the education system, the diagnosis should identify them from sectoral analyses, strategies, and action plans, define the problems that need to be solved, and consider the problems that digital technologies might be able to solve. To establish the extent of the digital readiness of the education and skills development system, the diagnosis should determine the opportunities, barriers, and risks for adapting, integrating, and scaling-up technology-enabled solutions in the sector. There are readily available frameworks, assessment methods, and related tools to help determine the most appropriate and contextually relevant strategies for incorporating digital solutions in education, which can be used to enable the digital transformation of any education system.

**A comprehensive assessment of the digital readiness of education and skills development systems is vital to inform government strategy and action plans and to ensure that the relevant actors align their approaches with the national education goals and priorities.** The diagnosis should provide essential insights into the maturity of relevant infrastructure, governance, capacity, core

education services, and market structures in the country. It should also consider the extent to which a country's overall approach in the digital area will support the achievement of high-quality education and skills development for all. A comprehensive view is needed to identify many critical systemic barriers to advance the digital transition, as these are not necessarily the most visible (for example, capacity and coordination) and may not be within the direct remit of the Ministries of Education.

**The Education Digital Readiness Assessments (EDRA) was conducted in Moldova, Georgia, and Kosovo between 2021 and 2024.** These assessments helped evaluate the education system's readiness to provide an objective diagnosis of the system across the five pillars outlined in [Section 4.1 Digital Readiness of the System](#). This helped identify and prioritize recommendations by mapping them to strategic education objectives that could most benefit from digital advancements; and inform a near- to medium-term policy action and implementation roadmap.<sup>393</sup> By triangulating various data sources and stakeholder insights, the diagnostic assessment can highlight the country's digital readiness and offer detailed recommendations to enhance the system's foundational, functional, and frontier digital capabilities, aiming to stimulate action and dialogue and help develop a transition roadmap. Systematic stakeholder mapping and engagement of various system-level actors and elements at the national, subnational, and school/community levels is often key to enabling and implementing digital transition initiatives ([Figure 16](#)).

These diagnostic assessments need to pay special attention to system-focused, equity- and inclusion-focused, and learning-focused indicators (Figure 15). While some tools include indicators that measure equity outcomes, they may not include other system-focused or learning-focused indicators. It is important to evaluate assessment tools based on whether they are people-centered, adequately draw interlinkages across various pillars, and sufficiently consider values such as equity, solidarity, inclusion, and human rights. Furthermore, it is important to critically consider not only what is assessed but also whose views and experiences are taken into account to inform policymaking. Assessing the digital readiness in any given country requires both a top-down and a bottom-up approach. Top-down perspectives include those of national, regional, and local institutions, committees, and private sector CxOs, while bottom-up perspectives include those of children, young people, parents, teachers, and school administrators. This can result in the diagnosis reflecting a balance of practice and policy and a focus on equity and inclusion.

**Table 1. Digital Readiness Assessment of the Education System**

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**Areas covered under each assessment pillar**

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**Pillar 1 - LEADERSHIP AND GOVERNANCE**

Vision and strategy  
Institutional capacity  
Legislation, policy, and compliance

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**Pillar 2 - ENABLING INFRASTRUCTURE**

Education enterprise architecture and data governance  
Connectivity  
Technology infrastructure  
Standards and services

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**Pillar 3 - DIGITALLY-ENABLED EDUCATION DELIVERY AND SCHOOL DIGITAL MATURITY**

Content standards and instructional materials  
Digitally empowered learning environment  
Digital skills of students  
Teacher's digital skills and pedagogical practices  
School management and administration

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**Pillar 4 - HUMAN CAPACITY**

Policymaking  
School ownership  
Wider public  
ICT professionalism

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**Pillar 5 - EDTECH MARKET AND BUSINESS MODELS**

Capacity and culture for entrepreneurship  
Development, uptake, and management of Edtech products and services  
Quality assurance of EdTech  
Support for innovative business models and public-private partnerships

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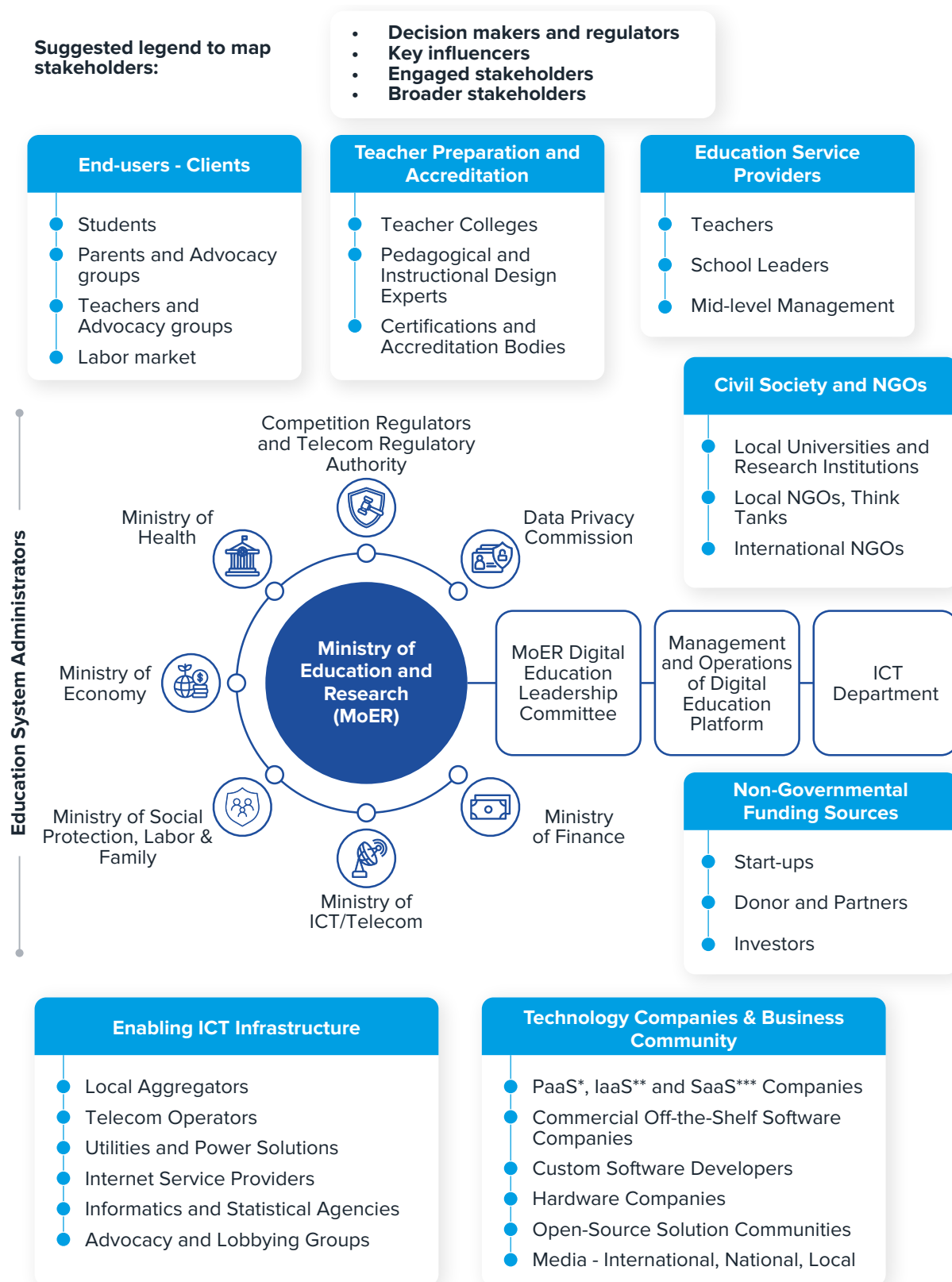
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*A comprehensive assessment of the digital readiness of education and skills development systems is vital to inform government strategy and action plans and to ensure that the relevant actors align their approaches with the national education goals and priorities.*

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In the next chapter, we discuss some of the key trade-offs that policymakers might consider when developing a digital transition roadmap for education and skills development.

**Figure 16. Illustrative Map of Education Ecosystem Stakeholders**



Source: Authors' analysis.

Note: This is an illustrative map that would need to be contextualized based on local and global trends, including emerging and new players; \*PaaS - Platform as a service; \*\*IaaS - Infrastructure as a service; \*\*\*SaaS - Software as a service

# 5 TAILORING DIGITAL PATHWAYS

Each country's unique contextual conditions and vision for its economy and society will drive which digital pathway that it adopts for education and skills development. There are at least three different pathways: (i) the overall digital ecosystem sets the direction and pace, with the education sector taking a passive role (for example, if the advent of connectivity and access to devices leads to teachers and schools incorporating digital resources in their teaching and learning); (ii) disruptive events or initiatives (from start-ups, private sector, or major international education initiatives) put external pressures on the sector to improve education services (for example, the pandemic catalyzed digitalization initiatives globally); or (iii) the education sector takes the lead (led by strategy at the top and/or by local initiatives from the local level) supported by an education-friendly digital ecosystem. While the first two pathways have been clear drivers in the digital transformation of education so far, the third pathway—taking a strategic approach led by education and skills development objectives—provides the most sustainable way forward as it ensures that relevant learning experiences and related goals stay at the core of any transformation efforts. This can be seen in the experiences of countries such as Singapore, Estonia, and South Korea.

**It is important to be sensitive to the local context and to tailor digital pathways accordingly when developing education and skills development policies and strategies.** Tailoring consists of deliberately considering and fine-tuning strategies and policies to address the diverse and dynamic needs within the specific country context when embedding digital technologies in education and skills development. This involves meticulously aligning educational policies with the broader and multifaceted policy ecosystem. It implies the need to craft policies that cater to diverse actors both within and outside the education sector and acknowledge the potential impact of these policies on a broad spectrum of education outcomes. The concept of tailoring underscores the importance of responsiveness in policy design. The aim should be to optimize the benefits of digital transformation while addressing the varied challenges and stakeholder interests involved in the educational landscape.

While a country or region will have its own pathway to digitally enable education and skills development systems, there may be overlaps with pathways that have been followed by other countries. Therefore, having a set of shared guidelines can be useful so as to not reinvent the wheel, to be aware of common pitfalls and challenges, and to learn from the experiences of others. At the same time, policymakers should be cautious about adopting the digital pathways taken by countries that do not share similar maturity levels and contexts as their own country. Moreover, the pervasive and interconnected consequences of digitalization on various aspects of education and skills development mean that careful thought must be given to balancing benefits against risks by actively recognizing the inherent trade-offs in policy decisions.

**This chapter delineates some of the critical trade-offs and common pitfalls in shaping digital transitions within education and skills development systems and underscores the need to take a strategic approach and to identifying effective ways to balance conflicting factors.** When considering adopting a risk-informed digital strategy across the education system, policymakers need to carefully consider their key trade-offs, the desired outcome, and the country's collective capability to manage the change process. While proactive public policy measures and a coherent systems approach can yield increased inclusivity and benefits, they may also incur higher costs and require strong leadership. On the other hand, adopting short-run trajectories may offer immediate private benefits but is likely to lead to fragmentation, greater social exclusion, and piecemeal results. For instance, an education policymaker with strategic or budgetary considerations that might choose to prioritize pressing concerns such as student safety, health and hygiene, and ensuring adequate number of trained teachers, while acquiring low-tech digital tools and solutions, thus taking an incremental pathway. Meanwhile, another country might choose a fully ICT-integrated curriculum while allowing teachers to gradually assimilate digital pedagogic practices. It is pivotal to balance realism with aspiration, ensure the durability of the adopted strategy, and acknowledge that the trade-offs made between different areas will affect the allocation of resources.



## 5.1 Trade-offs and Issues to Consider in the Design and Implementation of Digital Pathways

Policymakers often have to grapple with a variety of trade-offs when taking a decision on digital investments for education and skills development (see [Box 20](#)). It is imperative for policymakers and relevant ministries to proactively lead the charge for the digital transformation of the education sector by playing a strategic and hands-on role in shaping policies that drive the integration of digital technologies into education. By taking this proactive stance, policymakers can guide the transformation process and ensure that policies are tailored to meet the specific needs and challenges of their country's education system. They can also leverage the potential of digital innovations to enhance educational outcomes while effectively mitigating any potential disruptions, thus steering the course of the digital transformation in a controlled and purposeful manner rather than being passively influenced by external forces. In doing so, policymakers will need to tackle several trade-offs, with their decision depending on their motivation and vision, appetite for risk, the availability of fiscal space, and feasibility considerations such as whether workers with the relevant human capabilities are available.

**Policymakers may need to examine the implications of unlocking private sector innovation and new business models and build in appropriate mitigation measures:**

Private market engagement and competition to increase the availability of context-relevant digital solutions for education and skills development must be thoughtfully managed. For example, the prevalent practice of unbundling and rebundling digital components<sup>xxxix</sup> of education products and services may elevate the private good at the expense of the public good and create incoherent student experiences. This is particularly noticeable in higher education,<sup>394</sup> which is digitalizing at a rapid pace. Market-led approaches supported by newer business models are able to monetize all dimensions of the learning experience including curriculum and course development, teaching and learning resources, credentials and certifications, learning support and networks, flexible learning pathways and modalities, and even academic expertise.<sup>xl</sup> Moreover, in other subsectors, new EdTech products and services may initially be bundled for a lower price than the combined price of the individual components, which is simply economies of scale at work. However, market penetration enables firms to then unbundle and rebundle the offerings with the intention of elevating prices, including less useful products in the bundle (referred to as bloatware), or offering a complex mix of products at varying prices to apparently provide steep discounts. Such practices can put students and academic institutions at a disadvantage, cre-

ating an incoherent student experience and raising important questions about the role of the state.

It is necessary to consider the effect of existing governance structures and mechanisms on the design and implementation of education policies and programs

### Box 20. Possible Issues and Trade-offs to Consider for Policy Decision-Making

- Decisions based on total cost of ownership (TCO) or short-term investment and budget cycles
- Centralized or local-level equipment procurement and ownership
- Bearing of coordination costs for whole-of-government approach or business-as-usual siloed approach
- Data sharing within and/or beyond borders
- Data-driven efficiency vs. surveillance state
- International digital products vs. local innovation
- Policies that drive private benefits and fragmentation vs. Policies that drive public benefits and integration at scale
- Challenges with forecasting the competences (skills, knowledge, and attitudes) for the future
- Generalizability vs. contextualization and adaptation of digital solutions
- Speed/cost-effectiveness vs. contextualization of digital solutions
- Unbundling and rebundling of all aspects of education provision
- Equity at scale using low tech vs. staggered investments in high tech
- Speed and visible results vs. reform continuity and sustainable impact
- Centralized vs. decentralized digital governance of education administration processes
- Personalized and individualized learning vs. social learning through interaction and debate
- Deciding when, in what way and how much to allow the use of AI tools in schools
- Deciding whether to enable a 'bring your own device' policy in schools
- Offer options such as teachers plus tech or only tech or only teachers.

Source: Authors' compilation.

xxxix For example: e-readiness; program-level planning; course design and development; course delivery; course student support; course and program evaluation; and course maintenance/updates.

xl For example, freemium and subscription-based models.

**with digital affordances.** The centralized, semi-decentralized, and decentralized nature of governance mechanisms, including fiscal, political, and administrative governance, in the country's education systems have an outsized influence on how education policies and programs get implemented. Centralized governance structures have more control over standards and greater economies of scale, while decentralized governance structures allow for greater customization of solutions and much greater responsiveness to local needs. Decentralization is increasingly seen as the evolved response to the problems and excesses of centralized governance. It is hailed for increasing the efficiency and effectiveness of organizations, facilitating quicker reaction to problems, and improving service delivery, while also increasing accountability, discouraging corruption, and increasing cost recovery. Deciding to what extent and which aspects of digital and IT governance should be centralized or decentralized has significant implications. If policymakers value the benefits of standardization, efficiencies of scale and scope, and lower coordination costs, they may choose to reduce on-premises systems and increase bandwidth capacity and cloud migration by centralizing IT digital platforms.<sup>395</sup> However, concentrating governance power among platform owners may disadvantage and alienate platform participants (for example, third-party developers and end users) since platform owners can prioritize their own interests over those of stakeholders.<sup>396</sup> Hence, decentralized digital platforms based on distributed ledger technologies and Web3<sup>xli</sup>,<sup>397</sup> are being explored in some countries to enhance greater civic participation.<sup>398</sup>

**It is important to consider the implications of sharing education data and personal data and adopt relevant safeguards within the evolving landscape of EdTech.** While EdTech holds transformative potential for enhancing students' educational experiences and outcomes, concerns have surfaced about the invasion of learners' privacy, especially children, and about the lack of robust evidence supporting the learning benefits that have been claimed for EdTech. Policymakers must grapple with the nascent sector's complexities and need to consider restructuring the regulatory environment to safeguard students' interests. Balancing the roles of government and commercial organizations in EdTech provision is crucial and requires a governance framework that prioritizes the best interests of the student. The challenge lies in integrating information that is held in different databases, such as students' grades and engagement data, to understand student needs and preferences comprehensively. There may be a discrepancy in access to education records between ministries and private EdTech companies, often citing intellectual property (IP) or commercial reasons. This raises issues of reciprocity and the imperative to enable secure data sharing in public interest. Policymakers must strike a delicate

balance between unlocking the value of data for the public benefit, fostering innovation through open-source principles, ensuring robust governance methods that empower stakeholders, and addressing concerns over IP, particularly with regard to private organizations.<sup>399</sup>

**Inherent data privacy and cybersecurity challenges need to be carefully managed as any education system undergoes a digital transition.** While data-driven learning tools have the potential to enhance student outcomes substantially, the effective use of student data in K-12 schools remains in its early stages. The risks associated with data-driven instructional methods and perceptions surrounding these risks present significant obstacles to realizing the benefits of large-scale adoption of data and analytics in schools. Limited budgets, particularly in public schools, make it difficult to prioritize investment in data-driven tools and technologies. Using student data raises concerns about privacy, the risk of unauthorized access or sale of personal information to third parties, and the broader considerations of data collection and use within and outside the school system.<sup>400</sup> Policymakers must support education institutions in making informed investment decisions in digitally enabled education infrastructure by offering guidance on compliance with security and data protection frameworks and promoting interoperability frameworks to ensure compatibility between different digital learning environments.<sup>401</sup>

**Suitable institutional procurement strategies and budgetary practices are needed to ensure the judicious use of digital technologies within educational institutions.** This involves not only the provision of such necessary infrastructure as broadband connectivity and access to digital equipment but also institutional funding and human resource policies to ensure their effective management and use at the local level.<sup>402</sup> Often policymakers face trade-offs when making large-scale expensive procurements with up-front cost estimates being much less than estimates of the total cost of ownership (TCO), which could be three to seven times the initial investment. Finding a balance between up-front capital investments and the recurrent expenditures of using digital technologies is imperative for scale and sustainability. Furthermore, meticulous planning of resource allocation and matching is needed to handle logistical challenges, resource and capacity constraints, and organizational change management.<sup>403</sup> The carefully tailored allocation of fiscal and budgetary resources will facilitate the acquisition and deployment of digital education technologies in accordance with the country's overarching policy objectives. However, this undertaking is not without challenges, particularly in countries dealing with by severe financial constraints and/or hard-to-access rural settings.<sup>404</sup>

xli Web3 is an ecosystem in which information is distributed and collectively managed across a network (Stackpole 2022).

**There are coordination, financial, and political costs involved in translating strategic intentions of a digitally enabled education system into effective policy implementation.** Strategic documents are most effective in stimulating and coordinating policy reform when complemented by time-bound action plans that identify specific roles and responsibilities, establish shared governance structures, and specify funding arrangements. It is important to recognize that proposed policies do not operate in isolation but rather intersect with a spectrum of policies both within and outside the education sector, hence may only be realized by incurring significant coordination, financial, and political costs. The willingness or unwillingness of policymakers to bear these costs will make or break effective implementation. For example, policies related to regional development, tech sector regulations, and teacher professional development are vital for implementing digital strategies in education. Thus, policymakers must aim to align their strategic vision for digitally enabled education with the broader policy ecosystem to avoid a doubling of efforts and ensure synergy across various domains.

**Fostering the active participation of a wide range of stakeholders and recognizing the role of champions is imperative for successfully implementing digitally enabled education policies and action plans.** The engagement of stakeholders fulfills a multitude of functions, such as promoting innovation (through the participation of private enterprises, academic institutions, and research centers), assisting families in educating children about the educational potential and risks of digital technologies, and facilitating the procurement of digital technologies (through the involvement of local authorities). Policymakers need to investigate the protocols, systems and collaborative mechanisms that can be used to involve a diverse network of stakeholders. Effective and contextually relevant models of stakeholder engagement and public communication are needed to engage the stakeholders who influence how policies are implemented in the educational system, including but not limited to students, educators, administrators, and subnational governing bodies.

**Substantial time and effort are often needed to collaborate with authorities from other sectors to ensure a coherent policy approach and effective implementation of digitally enabled education focused on learning.** It is imperative to assess digitalization policies in education not in isolation but in the context of the governance environments in which they function while at the same time adjusting to the demands and potentialities of emerging technologies. The components of a strategic vision for digitally enabled education include: (i) establishing clear objectives that are connected to tangible policy actions on pedagogies, curricula, and assessment; (ii) providing direction and regulation for digitally enabled education; (iii) establishing essential pre-

requisites; (iv) allocating physical and human resources; (v) fostering capacity development; and (vi) establishing robust monitoring and evaluation systems.

**A strategic digital pathway for education must balance short-term policies against medium- to long-term policies as well as have the flexibility to accommodate changes and advances in response to social, technological, and economic shifts.** The adaptability of education strategies becomes paramount as new technologies emerge and needs from the field evolve. This flexibility and responsiveness are pivotal in a rapidly evolving field and can be ingrained at the design stage through purposeful feedback loops. These loops identify emerging needs, constraints, challenges, implementation issues, or undesirable effects, allowing policymakers to adjust their strategic directions as the digitally enabled education ecosystem evolves and matures. The ability to juggle short-term, medium-term, and long-term considerations, coordinate with relevant stakeholders, and make prudent fiscal trade-offs are all necessary digital education that aims for impactful and equitable outcomes.

## 5.2 Common Pitfalls in Shaping Digital Transitions

**Digitalization initiatives in many industries fail to reach their desired outcomes, in both public and private sector.** Reports from a variety of strategy consultants, such as BCG, McKinsey, and Bain, attest that only 15 to 25 percent of digital transformation initiatives end up meeting the planned business objectives. The many failed experiences of digital initiatives tend to share some common pitfalls observable across sectors and domains, several of which are also relevant in education. This section discusses some common challenges that have emerged from earlier digitalization efforts in education in various countries.

**Policymakers should try to avoid strategies that are device- or technology-centric and that view technology as an add-on.** Strategies often emphasize rolling out hardware or building infrastructure without including a clear pathway for how this will improve education delivery. Success is often quantified by inputs, such as the rollout of devices or the construction of computer labs, without acknowledging that these are only a means to achieve academic outcomes. Additionally, digitalization is often seen as a separate layer to be added onto an education component, as opposed to being built into it. For example, teaching and learning materials that may have been originally developed for traditional classroom instruction are simply approved to be digitized, instead of being redesigned from the outset using multimodal instructional design processes that emphasize interactive teaching and learning materials.

**Large-scale purchases of technology should not be made in the absence of an assessment and analysis of opportunity costs.** Large-scale technology purchases are often made without either testing the proof of concept of the technology in the intervention (especially considering the high failure rate of digital transformation initiatives) or budgeting for the TCO, such as device maintenance, training, change management, or curriculum reform, which can be five to ten times higher than the initial cost of acquisition.<sup>405</sup> Countries sometimes feel pressured to embark on large-scale technology procurement because of time-bound funding availability (for example, funds from a donor need to be used in a specific time period) or political reasons (for example, the need to distribute devices before an upcoming election cycle). It is better to make expensive digital technology investments in education after due consideration to the contextual needs and related opportunity costs.

**Inflexible, overly theoretical, long-term strategies often become outdated or limiting.** High-level decision-makers or external consultants may take many months to develop theoretical policies in boardrooms without engaging with local-level stakeholders such as local government authorities, teachers, students, parents, and communities to ensure their buy-in. These fixed, long-term plans cannot adapt to the changing technology landscape due to their complexity and lack of contextual knowledge. Furthermore, they are not resilient in terms of unforeseen events that might occur (for example, pandemics or natural disasters). As technology is fast evolving, regulations (for example, the need to store data locally) may lag or become outdated and restrictive.

**Government officials often lack the capacity, resources, and time to fully support digital transition efforts.** Government officials at the federal, state, district, and local levels often do not have the capacity, resources, and time to develop the required skill sets for going digital, particularly when it involves the use of new tools and processes. These skills may include data management, data analysis, instructional design, and software-specific digital literacy skills. Governments may also lack access to appropriate software or approvals to use software or data storage mechanisms. Even when officials have the necessary skill sets and training, they are often overloaded when new digitalization activities are added on top of their existing roles and responsibilities. Overloading is an issue of capacity management and resource allocation.

**Lack of stakeholders' buy-in as sufficient time and effort are not put into understanding and responding to their needs and pain points.** Without concluding a needs assessment with government authorities (at the state, regional, district levels) and with school managers and teachers, the

proposed system might not meet their needs. They may have different expectations from digitalization initiatives than those of policymakers. This may lead to difficulties in implementation and outright resistance at the school level because of a lack of motivation among teaching workforce. Similarly, different government agencies may have different interpretations of the country's digitalization strategy, resulting in a misalignment of efforts and poor investment decisions. These different approaches might be due to tensions between government agencies, power struggles, or political allegiances. Therefore, change management efforts might then be needed to overcome internal resistance.

**A lack of or poor-quality coordination, monitoring, evaluation, and accountability mechanisms can hamper the implementation of digitalization efforts.** In some countries, non-state actors such as private sector companies or NGOs are already implementing digitalization projects, but their activities are not always monitored or integrated with national digitalization plans. For example, a development agency may be rolling out digitalized teaching and learning materials that are incongruent with the national curriculum approval processes. In general, strategies often need to include sufficient monitoring and evaluation activities or fail to implement them at all or the frameworks are too complex to be carried out frequently and effectively. Monitoring and evaluation are also often treated as an afterthought as opposed to playing their essential role in the feedback loop for adaptation of the strategy and its implementation.

**Disjointed legacy platforms and applications can be too expensive to fit into improved systems.** While governments may acknowledge that systems can be improved, the cost, time, and approvals needed to update or merge them are high. For example, taking a building blocks approach to education data management makes sense in theory. However, when governments already have many stand-alone incompatible systems in place, the politics and costs of redesigning the underlying architecture can make it an unfeasible prospect.<sup>406</sup> This challenge is more acute in technologically advanced countries, while countries just starting to enter the digital realm have the advantage of being able to start with a clean slate and adopt an integrated system architecture from the outset.

**Data privacy, data usability, and data security concerns may be too lenient or too restrictive.** Governments may adopt data management processes that are either too strict or too lenient in terms of privacy and security. They may choose to restrict the hosting of education data to local data centers with the intention to maximize security. However, by doing so, they then limit the availability and usability of the data and increase the risk of entire plat-



forms going offline if local data centers malfunction. Conversely, a government may choose to transition to public cloud hosting for greater flexibility, but without necessary safeguards, this opens the data up to risks of exfiltration or cyberattacks. Therefore, before aggregated data can be shared openly to support better decision-making, it is vital to take proper measures for data anonymization, cleaning, and security. But this process may be considered cumbersome and a bottleneck to making data open.

The following section draws on these lessons to outline some effective ways to overcome these challenges.

### 5.3 Effective Practices for Digital Transitions in Education

**Due to the rapid evolution of technology, digitalization strategies must be flexible, adaptive, and iterative to remain relevant.** Traditionally, the development of a strategy or policy precedes the implementation of a digital solution which can put the brakes on the rapid adoption of the solution. Since most challenges discussed in the previous section are human-centered implementation challenges rather than technology-centered issues, the guidelines outlined here are intended to address implementation challenges from the onset.

**First and foremost, policymakers must begin with education sector problems, identify those solvable using digital technologies and set clear milestones and goals.** As mentioned in [Section 5.1](#), it is not possible to implement all interventions envisioned in a strategy at once. Instead, the plan needs to focus on the specific, urgent challenges that the country is facing, which can be determined through a comprehensive analysis of the education sector. The goals that are set in the plan should balance comprehensiveness and feasibility, while recognizing that digitalization does not solve all problems and may not always be the best solution.<sup>407</sup>

**The goals of the plan should be aligned with broader education sector plans, existing and planned national ICT infrastructure, and digitalization plans in other sectors.**<sup>408</sup> When policies related to ICT in education synchronize with other sector's plans, costs can be shared, and benefits can be optimized. For example, digital architecture can be shared between primary and higher education or between education and health systems. Broader digitalization plans, such as providing connectivity, overlap strongly with connectivity availability in schools. Installing undersea fiber optic cables or developing digital learning platforms in shared languages may require greater regional cooperation. In addition to aligning with other plans, ICT in education policies should align with what aspects of governance are centralized and decentralized and other political economy considerations. Context-specific factors, such as socioeconomic or emergency variations between regions, should be taken into account to ensure that policies can adapt to diverse needs.

**It is useful to adopt agile delivery approaches where possible and when applicable to develop responsive policies and plans.**<sup>409</sup> These approaches start with a discovery phase where actors seek to understand a problem (as discussed in [Chapter 4](#)), and then iteratively implement alpha, beta, and trial phases to test, adapt, and improve as the policy is scaled up. In the alpha stage, multiple prototypes of different approaches and ideas might be tested to determine what works most effectively and appropriately within a given context. Using this methodology can prevent the development of theoretical plans that might not work in practice (See [Figure 17](#)).

**Digital transition policies must take into account different dimensions and layers of the education system as well as their governance arrangements to achieve policy coherence and alignment.** To maintain adaptability and relevance, the policy ecosystem should incorporate feedback loop mechanisms to inform adjustments to the strat-

**Figure 17. Example of an Agile Delivery Approach**



egy in response to evolving trends and insights from stakeholders. This dynamic and integrated approach ensures that the digitally enabled education policy ecosystem remains responsive and effective in addressing the evolving needs of education systems.<sup>410</sup>

**Digital aspects should be considered and integrated into intervention design upfront, with inclusion, scale and sustainability for optimal impact.** Scale cannot be an afterthought. Many interventions fail because the pilot projects are not scalable.<sup>411</sup> Designing for scale means considering user costs, partners, funding models, and technology choices upfront.<sup>412</sup> Crucially, a major difference between pilots and scaled projects is the amount of implementation and human support that is needed for the scale-up, which is often too costly. McLean et al (2020) have argued that, instead of scaling up (for example, training more teachers) or scaling out (for example, equipping more teacher resource centers), the focus should be on scaling impact. They outline four guiding principles for planning to scale for impact: (i) justify whether something can and should be scaled; (ii) optimize scale by making trade-offs, such as equity versus sustainability; (iii) coordinate different complex systems requiring multi-stakeholder engagement, flexibility, and adaptability; and (iv) dynamically evaluate the how taking a different action affects impact, considering, why, for whom, and under what conditions.

**Collaborations between different government stakeholders can facilitate a systems way of thinking, encourage trust and drive greater coherence and alignment<sup>413</sup>.** As highlighted in UNICEF's Pulse Check on Digital Learning<sup>414</sup>, strategies that overlook the human element have higher failure rates. Systems become more effective when they focus on learning instead of on technologies or devices.<sup>415</sup> Learning applies not only to students and teachers but also to government officials at the federal, state, and local levels and all other stakeholders in the education ecosystem. Adopting a systems approach involves understanding the dynamics and complexity of interacting variables in a system, including stakeholders, policies, global events, regulations, and cross-sectoral influences.<sup>416</sup>

**It is vital that decision makers periodically update the strategy in response to technological changes.** It is important for a flexible, adaptable and collaborative approach in designing and implementing the strategy. This goes beyond soliciting stakeholder input to co-creating environments where various stakeholders can continuously and actively participate in sense-making.<sup>417,418</sup> To ensure that the strategy remains responsive and resilient, it will need to be updated periodically, which is not usually the case with other strategies and policies.

**Decision-makers should focus on the usability of their country's national education management information system (EMIS) rather than on producing data dashboards as an end in itself.** It is crucial that decisions regarding what an EMIS should measure and how it should operate should be influenced by the country's education policies and priorities. Policymakers should be able to use data to evaluate what progress is being made towards the achievement of those priorities. Therefore, data architects must understand the relevant policies and implement the necessary functionality accordingly. For instance, there is considerable demand for data pertaining to mandates regarding equity and equality to see if children of all demographic backgrounds are receiving the education to which they are entitled. Additionally, an EMIS could provide analysts with timely information on increases in school dropout rates and the factors that contribute to them.

**Providing guidance, standards, and formal regulations is crucial to ensuring the safe and effective use of digital technology in education systems.** The growing cybersecurity risks, data protection concerns, and potential algorithmic bias make it necessary for policymakers to pay closer attention to complying with existing digital security and data protection frameworks and to developing regulations in currently uncovered areas. Continuous regulatory efforts are essential to address privacy concerns<sup>xiii</sup> and limit inequitable practices as educational technologies evolve. Lessons can be learned from other industries that use data to improve the user experiences while embracing transparent data use to improve results.

<sup>xiii</sup> The EdTech industry has been compared to regulation in the medical industry in regard to how it could be regulated: "If it is not allowed to sell ineffective medicine, why should we allow the selling of ineffective learning tools?"

# 6 CONCLUSION

**A new collective understanding of digitally enabled education systems is needed to achieve greater learning and well-being for all.** Digital technologies are offering new tools through which learning goals can be achieved. However, this does not mean that achieving better outcomes in a digital world depends only on the rapid adoption of new technologies in education systems. It crucially depends on decision-makers taking a value-based and purposeful approach to the discovery and design of digital solutions and innovations in education, diffuse the benefits of digital education technologies equitably and deploy them in an economically feasible way.<sup>419</sup>

**The pandemic experience demonstrated the enormous cost to societies when education systems are not fit for purpose and are unprepared in the face of crisis.**<sup>420</sup> Digital education technologies, while not a panacea, provide a minimum of services. They enable countries to be more resilient. During the pandemic, countries with a relatively mature digital backbone, an enabling ecosystem, and relevant digital capabilities in education were able to switch to and expand emergency remote education services<sup>xliii</sup> more rapidly and successfully than those with less digitally mature education systems. However, when those digital solutions were not well thought through, contextually tailored, and evidence based, they failed to meet their purpose, incurring significant opportunity costs.

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*In the end, the human side of the human-machine interface determines how technology can best serve education policymakers, administrators, service providers, teachers, and the community of students and parents.*

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**Today's education policymakers must choose contextually relevant digital pathways that help build a well-endowed and competitive labor force fit for dynamic and digitally intense labor markets.** As every aspect of the digital economy is powered by people, education is both the key constraint and a key enabler of a successful digital transition. Hence, individuals need to be both avid pro-

ducers and rapid consumers of the right skills, knowledge, and behaviors. At the same time, there is intrinsic value in education as part of the human endeavor to learn, grow, and participate in civil society as active and responsible citizens. Increasingly, civic participation is enabled through access to digital services, financial transactions, tax payments, voting, and many digital government services. In the end, the human side of the human-machine interface determines how technology can best serve education policymakers, administrators, service providers, teachers, and the community of students and parents.

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<sup>xliii</sup> For example, in Uruguay, a pioneer in Latin America and the Caribbean region with an exemplary educational technology initiative since 2007, early investments in education technology are paying off. Every student had access to a personal computer and internet. Short videos and follow-up activities can be broadcast weekly using the national online learning platform. Teachers know how to work remotely using interactive lesson plans with students and set weekly goals for learners. Thus, Uruguay's Ceibal at-home program was launched immediately after school closures because it could draw on the preexisting systematic deployment of Plan Ceibal's digital capability.

# REFERENCES

1. Monton, A. L. (2022, March 22). Difference and Similarities: Digitization, Digitalization, and Digital Transformation. GlobalSign. <https://www.globalsign.com/en-sg/blog/difference-and-similarities-digitization-digitalization-and-digital-transformation> (details)
  2. Bloomberg, J. (2018). Digitization, Digitalization, and Digital Transformation: Confuse Them At Your Peril. Forbes. <https://www.forbes.com/sites/jasonbloomberg/2018/04/29/digitization-digitalization-and-digital-transformation-confuse-them-at-your-peril/> (details)
  3. Adkins, S. S. (2020). The 2019 Global Learning Technology Investment Patterns: Another Record Shattering Year. <https://users.neo.registeredsite.com/9/8/1/17460189/assets/Metaari-2019-Global-Learning-Technology-Investment-Patterns.pdf> (details)
  4. Chiu, T. K. F., Xia, Q., Zhou, X., Chai, C. S., & Cheng, M. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. Computers and Education: Artificial Intelligence, 4, 100118. <https://doi.org/10.1016/j.caeai.2022.100118> (details)
  5. Saavedra, C., Jaime, A. I., Mario, C. A. D., & Omar, S. (2020). Realizing the future of learning: From learning poverty to learning for everyone, everywhere. World Bank, 154703. <https://documents1.worldbank.org/curated/en/250981606928190510/pdf/Realizing-the-Future-of-Learning-From-Learning-Poverty-to-Learning-for-Everyone-Everywhere.pdf>
  6. Goldin, C., & Katz, L. F. (2018). The race between education and technology. In *Inequality in the 21st Century* (pp. 49–54). Routledge. <https://www.taylorfrancis.com/chapters/edit/10.4324/9780429499821-10/race-education-technology-claudia-goldin-lawrence-katz> (details)
- Tinbergen, J. (1974). Substitution of graduate by other labour. *Kyklos: International Review for Social Sciences*. <https://repub.eur.nl/pub/8084/1974Kyklos.pdf> (details)
- De Siqueira, A. C. (2012). The 2020 World Bank education strategy: Nothing new, or the same old gospel. In *The World Bank and Education* (pp. 67–81). Brill. <https://brill.com/downloadpdf/book/9789460919039/BP000006.pdf> (details)
7. Ganimian, Vegas, and Hess 2020; National Academy of Science, Engineering, and Medicine 2000.
- Ganimian, A. J., Vegas, E., & Hess, F. M. (2020, September 10). Realizing the promise: How can education technology improve learning for all? Brookings. <https://www.brookings.edu/essay/realizing-the-promise-how-can-education-technology-improve-learning-for-all/> (details)
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn* (Vol. 11). Washington, DC: National academy press. <https://nap.nationalacademies.org/catalog/9853/how-people-learn-brain-mind-experience-and-school-expanded-edition>
- National Academies of Sciences, Division of Behavioral, Board on Science Education, Board on Behavioral, Sensory Sciences, Committee on How People Learn II, ... & Practice of Learning. (2018). *How people learn II: Learners, contexts, and cultures*. National Academies Press. <https://nap.nationalacademies.org/catalog/24783/how-people-learn-ii-learners-contexts-and-cultures>
- Darling-Hammond, L., & Oakes, J. (2021). *Preparing teachers for deeper learning*. Harvard Education Press.
- Darling-Hammond, L., Oakes, J., Wojcikiewicz, S., Hyler, M. E., Guha, R., Podolsky, A., Kini, T., Cook-Harvey, C., Mercer, C., & Harrell A. (2019). *Preparing Teachers for Deeper Learning* (research brief). Palo Alto, CA: Learning Policy Institute.
- De Felice, S., Hamilton, A. F. D. C., Ponari, M., & Vigliocco, G. (2023). Learning from others is good, with others is better: the role of social interaction in human acquisition of new knowledge. *Philosophical Transactions of the Royal Society B*, 378(1870), 20210357. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9791495/>
8. Kucirkova, N., Brod, G., & Gaab, N. (2023). Applying the science of learning to EdTech evidence evaluations using the EdTech Evidence Evaluation Routine (EVER). *Npj Science of Learning*, 8(1), 35. <https://doi.org/10.1038/s41539-023-00186-7> (details)



- Frau-Meigs, D., & Hibbard, L. (2016). Education 3.0 and Internet Governance: A new global alliance for children and young people's sustainable digital development. [https://www.cigionline.org/sites/default/files/gcig\\_no27web\\_0.pdf](https://www.cigionline.org/sites/default/files/gcig_no27web_0.pdf) (details)
9. Vegas, E., Ziegler, L., & Zerbino, N. (2019, November 20). How ed-tech can help leapfrog progress in education. Center for Universal Education at The Brookings Institution. <https://eric.ed.gov/?id=ED602936> (details)
10. Olsen, B. (2023). Government Decision-Making on Education in Low- and Middle-Income Countries: Understanding the Fit among Innovation, Scaling Strategy, and Broader Environment. <https://www.brookings.edu/wp-content/uploads/2023/08/Olsen-2023.pdf> (details)
11. Labun, J. (2023). Fixing Ed-Tech's Investment Model. [https://ssir.org/articles/entry/fixing\\_ed\\_techs\\_investment\\_model](https://ssir.org/articles/entry/fixing_ed_techs_investment_model). (details)
12. Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps lessons from the science of learning. *Psychological Science in the Public Interest*, 16(1), 3-34.
13. Autor, D. (2022). The labor market impacts of technological change: From unbridled enthusiasm to qualified optimism to vast uncertainty. National Bureau of Economic Research. <https://www.nber.org/papers/w30074> (details)
- Facer, K., & Selwyn, N. (2021). Digital technology and the futures of education: Towards 'Non-Stupid' optimism. Paper Commissioned for the UNESCO Futures of Education Report. [https://www.academia.edu/download/98619725/Unesco\\_Background\\_Ed\\_Tech.pdf](https://www.academia.edu/download/98619725/Unesco_Background_Ed_Tech.pdf) (details)
- Shapiro, S. L., Schwartz, G. E., & Bonner, G. (1998). Effects of Mindfulness-Based Stress Reduction on Medical and Premedical Students. *Journal of Behavioral Medicine*, 21(6), 581–599. <https://doi.org/10.1023/A:1018700829825> (details)
14. Cullinan, J., Flannery, D., Harold, J., Lyons, S., & Palcic, D. (2021). The disconnected: COVID-19 and disparities in access to quality broadband for higher education students. *International Journal of Educational Technology in Higher Education*, 18(1), 26. <https://doi.org/10.1186/s41239-021-00262-1> (details)
15. Rajasekaran, S., & Casap, L. (2022). Moldova – Digital Education Readiness Assessment 2021-22. World Bank Group.
- Godaert, E., Aesaert, K., Voogt, J., & Van Braak, J. (2022). Assessment of students' digital competences in primary school: a systematic review. *Education and Information Technologies*, 27(7), 9953–10011. <https://doi.org/10.1007/s10639-022-11020-9> (details).
- Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science and Technology Education*, 5(3), 235–245. <https://doi.org/10.12973/ejmste/75275> (details)
- Freeman, A., Becker, S. A., & Cummins, M. (2017). NMC/CoSN horizon report: 2017 K. The New Media Consortium. <https://www.learntechlib.org/p/182003/> (details)
- Omidyar Network. (2019). Scaling Access & Impact Realizing the Power of EdTech. [https://assets.imaginablefutures.com/media/documents/ON\\_Scaling\\_Access\\_Impact\\_2019\\_85x11\\_Online.pdf](https://assets.imaginablefutures.com/media/documents/ON_Scaling_Access_Impact_2019_85x11_Online.pdf) (details)
16. Rajasekaran, S., & Casap, L. (2022). Moldova – Digital Education Readiness Assessment 2021-22. World Bank Group. <http://documents.worldbank.org/curated/en/099120006252220689/P17773104ea-6f2040a88e02bdf9bbd04f6>. (details)
17. Gkrimpizi, T., Peristeras, V., Magnisalis, I. (2023) Classification of Barriers to Digital Transformation in Higher Education Institutions: Systematic Literature Review, <https://www.mdpi.com/2227-7102/13/7/746>
18. International Commission on the Futures of Education. (2021). Reimagining our futures together: a new social contract for education. UNESCO. <https://doi.org/10.54675/ASRB4722> (details)
- United Nations. (2022). Assuring and improving quality public digital learning for all. United Nations. <https://www.un.org/en/transforming-education-summit/digital-learning-all> (details)
19. A4AI. (2022). Meaningful Connectivity — unlocking the full power of internet access. Alliance for Affordable Internet. <https://a4ai.org/meaningful-connectivity/>. (details)
20. Hodges, C. B., Moore, S., Lockee, B. B., Trust, T., & Bond, M. A. (2020). The difference between emergency remote teaching and online learning. <https://vtechworks.lib.vt.edu/handle/10919/104648> (details)
21. UNESCO. (2017). The world is off track in achieving the global education goal, SDG 4 - UNESCO Digital Library. <https://unesdoc.unesco.org/ark:/48223/pf0000368935> (details)
22. UNICEF. (2020, August 26). COVID-19: Are children able to continue learning during school closures? UNICEF DATA. <https://data.unicef.org/resources/remote-learning-reachability-factsheet/> (details)

23. The World Bank. (2018). World Development Report 2018: Learning to realize education's promise. ([details](#))
24. The Chronicle. (2020, June 30). How the Education System Exacerbates Inequality. The Chronicle of Higher Education. <https://www.chronicle.com/article/how-the-education-system-exacerbates-inequality> ([details](#))
25. World Bank. (2023). Open Knowledge Repository. <https://openknowledge.worldbank.org/entities/publication/211c4d69-9013-4942-831f-4dbae5ede977?deliveryName=DM209153>. ([details](#)) Available under "World Bank. 2023. Making Teacher Policy Work. © Washington, DC: World Bank. <http://hdl.handle.net/10986/40579> License: CC BY 3.0 IGO."
26. The State of Global Learning Poverty: 2022 Update. (2022). <https://thedocs.worldbank.org/en/doc/e52f55322528903b27f1b7e61238e416-0200022022/original/Learning-poverty-report-2022-06-21-final-V7-0-conferenceEdition.pdf> ([details](#))
27. GEM Report UNESCO. (2023). Global Education Monitoring Report 2023: Technology in education: A tool on whose terms? (1st ed.). GEM Report UNESCO. <https://doi.org/10.54676/UZQV8501> ([details](#))
28. Archer, D. (2023). Transforming the financing of education at the mid-point of the sustainable development goals. International Journal of Educational Development, 103, 102931. <https://doi.org/10.1016/j.ijedudev.2023.102931> ([details](#))
29. End the killing of children in armed conflict, UN committee urges. (2023). <https://www.ohchr.org/en/statements/2023/11/end-killing-children-armed-conflict-un-committee-urges> ([details](#))
30. Bend, M., Hu, Y., Pan, Y., Patrinos, H. A., Poulsen, T., Rivera-Olvera, A., Tanaka, N., Antoninis, M., Murakami, Y., & Benveniste, L. (2023). Education Finance Watch 2023. <https://policycommons.net/artifacts/6951221/education-finance-watch-2023-english/7861178/> ([details](#))
31. UNICEF, I. T. U. (2020). Two Thirds of the World's School-Age Children Have No Internet Access at Home, New UNICEF-ITU Report Says. <https://www.unicef.org/press-releases/two-thirds-worlds-school-age-children-have-no-internet-access-home-new-unicef-itu> ([details](#))
32. Díaz, S., Settele, J., Brondízio, E. S., Ngo, H. T., Agard, J., Arneeth, A., Balvanera, P., Brauman, K. A., Butchart, S. H. M., Chan, K. M. A., Garibaldi, L. A., Ichii, K., Liu, J., Subramanian, S. M., Midgley, G. F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., ... Zayas, C. N. (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. Science, 366(6471), eaax3100. <https://doi.org/10.1126/science.aax3100> ([details](#))
33. United Nations. (2022). World Population Prospects 2022. United Nations, Department of Economic and Social Affairs, Population Division. [https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022\\_summary\\_of\\_results.pdf](https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf) ([details](#))
34. Chiu, T. K. F., Xia, Q., Zhou, X., Chai, C. S., & Cheng, M. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. Computers and Education: Artificial Intelligence, 4, 100118. <https://doi.org/10.1016/j.caeai.2022.100118> ([details](#))
35. Facer, K., & Selwyn, N. (2021). Digital technology and the futures of education: Towards 'Non-Stupid' optimism. Paper Commissioned for the UNESCO Futures of Education Report. [https://www.academia.edu/download/98619725/Unesco\\_Background\\_Ed\\_Tech.pdf](https://www.academia.edu/download/98619725/Unesco_Background_Ed_Tech.pdf) ([details](#))
36. Reich, J., Buttner, C. J., Fang, A., Hillaire, G., Hirsch, K., Larke, L. R., Littenberg-Tobias, J., Moussapour, R. M., Napier, A., & Thompson, M. (2020). Remote learning guidance from state education agencies during the COVID-19 pandemic: A first look. <https://doi.org/10.35542/osf.io/437e2> ([details](#))
37. Baird, S. J., Garfein, R. S., McIntosh, C. T., & Özler, B. (2012). Effect of a cash transfer programme for schooling on prevalence of HIV and herpes simplex type 2 in Malawi: a cluster randomised trial. The Lancet, 379(9823), 1320–1329. [https://doi.org/10.1016/S0140-6736\(11\)61709-1](https://doi.org/10.1016/S0140-6736(11)61709-1) ([details](#))
38. A4AI. (2022). Meaningful Connectivity — unlocking the full power of internet access. Alliance for Affordable Internet. <https://a4ai.org/meaningful-connectivity/>. ([details](#))
39. International Commission on the Futures of Education. (2021). Reimagining our futures together: a new social contract for education. UNESCO. <https://doi.org/10.54675/ASRB4722> ([details](#))
- United Nations. (2022). Assuring and improving quality public digital learning for all. United Nations. <https://www.un.org/en/transforming-education-summit/digital-learning-all> ([details](#))
40. Goldin, C., & Katz, L. F. (2018). The race between education and technology. In Inequality in the 21st Century (pp. 49–54). Routledge. <https://www.taylorfrancis.com/chapters/edit/10.4324/9780429499821-10/race-education-technology-claudia-goldin-lawrence-katz> ([details](#))

- Tinbergen, J. (1974). Substitution of graduate by other labour. *Kyklos: International Review for Social Sciences*. <https://repub.eur.nl/pub/8084/1974Kyklos.pdf> (details)
- The World Bank. (2018). World Development Report 2018: Learning to realize education's promise. (details)
- De Siqueira, A. C. (2012). The 2020 World Bank education strategy: Nothing new, or the same old gospel. In *The World Bank and Education* (pp. 67–81). Brill. <https://brill.com/downloadpdf/book/9789460919039/BP000006.pdf> (details)
41. Ganimian, Vegas, and Hess 2020; National Academy of Science, Engineering, and Medicine 2000.

Ganimian, A. J., Vegas, E., & Hess, F. M. (2020, September 10). Realizing the promise: How can education technology improve learning for all? Brookings. <https://www.brookings.edu/essay/realizing-the-promise-how-can-education-technology-improve-learning-for-all/> (details)

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn* (Vol. 11). Washington, DC: National academy press. <https://nap.nationalacademies.org/catalog/9853/how-people-learn-brain-mind-experience-and-school-expanded-edition>

National Academies of Sciences, Division of Behavioral, Board on Science Education, Board on Behavioral, Sensory Sciences, Committee on How People Learn II, ... & Practice of Learning. (2018). *How people learn II: Learners, contexts, and cultures*. National Academies Press. <https://nap.nationalacademies.org/catalog/24783/how-people-learn-ii-learners-contexts-and-cultures>

Darling-Hammond, L., & Oakes, J. (2021). *Preparing teachers for deeper learning*. Harvard Education Press.

Darling-Hammond, L., Oakes, J., Wojcikiewicz, S., Hyler, M. E., Guha, R., Podolsky, A., Kini, T., Cook-Harvey, C., Mercer, C., & Harrell A. (2019). *Preparing Teachers for Deeper Learning* (research brief). Palo Alto, CA: Learning Policy Institute.

De Felice, S., Hamilton, A. F. D. C., Ponari, M., & Vigliocco, G. (2023). Learning from others is good, with others is better: the role of social interaction in human acquisition of new knowledge. *Philosophical Transactions of the Royal Society B*, 378(1870), 20210357. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9791495/>
42. Autor, D. (2022). The labor market impacts of technological change: From unbridled enthusiasm to qualified optimism to vast uncertainty. National Bureau of Economic Research. <https://www.nber.org/papers/w30074> (details)
- Facer, K., & Selwyn, N. (2021). Digital technology and the futures of education: Towards 'Non-Stupid' optimism. Paper Commissioned for the UNESCO Futures of Education Report. [https://www.academia.edu/download/98619725/Unesco\\_Background\\_Ed\\_Tech.pdf](https://www.academia.edu/download/98619725/Unesco_Background_Ed_Tech.pdf) (details)
- Shapiro, S. L., Schwartz, G. E., & Bonner, G. (1998). Effects of Mindfulness-Based Stress Reduction on Medical and Premedical Students. *Journal of Behavioral Medicine*, 21(6), 581–599. <https://doi.org/10.1023/A:1018700829825> (details)
43. World Bank. 2024. Digital Progress and Trends Report 2023. © Washington, DC: World Bank. <http://hdl.handle.net/10986/40970>  
<https://openknowledge.worldbank.org/entities/publication/7617f89d-2276-413d-b0a7-e31e7527d6af>
44. Hawkins, Robert J.; Trucano, Michael; Cobo Romani, Juan Cristobal; Twinomugisha, Alex; Sanchez Ciarrusta, Inaki Alejandro.

Reimagining Human Connections : Technology and Innovation in Education at the World Bank (English). Washington, D.C. : World Bank Group. <http://documents.worldbank.org/curated/en/829491606860379513/Reimagining-Human-Connections-Technology-and-Innovation-in-Education-at-the-World-Bank>
45. Soegaard, M. (2015, July 5). Affordances. Interaction Design Foundation - IxDF. <https://www.interaction-design.org/literature/book/the-glossary-of-human-computer-interaction/affordances>
46. UNICEF. (2022). Pulse Check on Digital Learning. <https://www.unicef.org/reports/pulse-check> (details)
47. Education Technology Market Size & Share Report, 2030. (n.d.). Retrieved February 29, 2024, from <https://www.grandviewresearch.com/industry-analysis/education-technology-market> (details)
48. Engaging the private sector for stronger, more dynamic education - Creative. (2020, November 2). <https://www.creativeassociatesinternational.com/insights/engaging-the-private-sector-for-stronger-more-dynamic-education/> (details)
49. Transforming Education Summit, 2022; UNESCO Commission on Futures of Education, 2021
50. UNICEF. (2022). Pulse Check on Digital Learning. UNICEF. <https://www.unicef.org/media/132096/file/Pulse%20Check.pdf> (details)

51. Coflan, C., Wyss, N., Thinley, S., & Roland, M. (2022). Developing a national EdTech strategy. EdTech Hub. ([details](#))
52. Shapiro, S. L., Schwartz, G. E., & Bonner, G. (1998). Effects of Mindfulness-Based Stress Reduction on Medical and Premedical Students. *Journal of Behavioral Medicine*, 21(6), 581–599. <https://doi.org/10.1023/A:1018700829825> ([details](#))
53. Kelly, P. (2023). 5 Challenges of Digital Transformation in the Public Sector. GovNet. <https://blog.govnet.co.uk/technology/5-challenges-of-digital-transformation-in-the-public-sector> ([details](#))
54. ITU. (2021, October 14). Ministerial Roundtable - “Digitalizing daily life: government services and content driving digital transformation” – Part 1 - ITU Telecom World. <https://digital-world.itu.int/ministerial-roundtable-digitalizing-daily-life-government-services-and-content-driving-digital-transformation-part-1/> ([details](#))
55. ITU. (2021, October 14). Ministerial Roundtable - “Digitalizing daily life: government services and content driving digital transformation” – Part 1 - ITU Telecom World. <https://digital-world.itu.int/ministerial-roundtable-digitalizing-daily-life-government-services-and-content-driving-digital-transformation-part-1/> ([details](#))
56. Kamp-Hartong, S., Piattoeva, N., Saari, A., & Savage, G. (2022). Transformation of Education Policy and Governance in the Digital Era. <https://academic.oup.com/book/41546/chapter/353003648>. ([details](#))
57. Brazil : The SOL-ution for Smart Community Procurement. (2022). World Bank. <https://doi.org/10.1596/37687> ([details](#))
58. Hallward-Driemeier, Mary; Nayyar, Gaurav; Gill, Indermit; Aridi, Anwar. (2020). Europe 4.0: Addressing the Digital Dilemma. World Bank, Washington DC. <http://hdl.handle.net/10986/34746>
59. e-Estonia guide (n.d.). Retrieved March 19, 2024, from <https://e-estonia.com/wp-content/uploads/eas-eestonia-vihik-a5-180404-view.pdf> ([details](#))
- Heikkilä, J., & Penttinen, K. (2016). Overview of Enterprise Architecture work in 15 countries. ([details](#))
- Mayakul, T., Sa-Nga-Ngam, P., Srisawat, W., & Kiattisin, S. (2019). A Comparison of National Enterprise Architecture and e-Government Perspectives. 2019 4th Technology Innovation Management and Engineering Science International Conference (TIMES-ICON), 1–6. <https://doi.org/10.1109/TIMES-ICON47539.2019.9024591> ([details](#))
- Ministry Economic Affairs and Communications. (2011). Interoperability of the State Information System version 3.0. ([details](#))
60. Welland, A. (2017). Education and the electrification of rural schools. [https://e4sv.org/wp-content/uploads/2017/05/TR13-Education-and-the-Electrification-of-Rural-Schools\\_web-1.pdf](https://e4sv.org/wp-content/uploads/2017/05/TR13-Education-and-the-Electrification-of-Rural-Schools_web-1.pdf) ([details](#))
61. Welland, A. (2017). Education and the electrification of rural schools. [https://e4sv.org/wp-content/uploads/2017/05/TR13-Education-and-the-Electrification-of-Rural-Schools\\_web-1.pdf](https://e4sv.org/wp-content/uploads/2017/05/TR13-Education-and-the-Electrification-of-Rural-Schools_web-1.pdf) ([details](#))
62. Utilities One. (2023, November 24). The Impact of Broadband Network Construction on Education. Utilities One. <https://utilitiesone.com/the-impact-of-broadband-network-construction-on-education> ([details](#))
63. The Economist 2021.
64. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. (2017). Data for development: What's next? Concepts, trends and recommendations for German development cooperation. [https://webfoundation.org/docs/2018/01/Final\\_Data-for-development\\_Whats-next\\_Studie\\_EN.pdf](https://webfoundation.org/docs/2018/01/Final_Data-for-development_Whats-next_Studie_EN.pdf) ([details](#))
- Gustafsson-Wright, E., Osborne, S., & Aggarwal, M. (2022). Digital tools for real-time data collection in education. <https://policycommons.net/artifacts/4142237/digital-tools-for-real-time-data-collection-in-education/4951284/> ([details](#))
65. Goger, A., Parco, A., Carter-Rau, R., Homma, K., Meliksetyan, A., & Milman, N. (2022). How learning and employment records shape access to quality education and jobs. Brookings. ([details](#))
66. Bethel, E. C. (2014). A Systematic Review of One-to-One Access to Laptop Computing in K-12 Classrooms: An Investigation of Factors That Influence Program Impact. ([details](#))
- McKinsey. (2022). Digital trust: Why it matters for businesses | McKinsey. <https://www.mckinsey.com/capabilities/quantumblack/our-insights/why-digital-trust-truly-matters> ([details](#))
67. Di Maio, G., Seitzl, L., & Unterweger, D. F. (2020). Strengthening the Governance of Skills Systems: Lessons from Six OECD Countries. <https://www.alexandria.unisg.ch/handle/20.500.14171/112292> ([details](#))
68. Secretary of Education of Guanajuato. (2021). RIMA - Recopilación de información para la mejora de los aprendiza-



jes: Informe de resultados evaluación de Matemática y Español RIMA2020 y 2021 [Results report of the evaluation of Mathematics and Spanish RIMA 2020 and 2021]. ([details](#))

Secretary of Education of Guanajuato. (2021). RIMA - Recopilación de información para la mejora de los aprendizajes: Manual del proceso (aplicación y devolución de resultados). [RIMA - Collection of information for improving learning: Process manual (application and return of results)]. ([details](#))

69. Kaufman, D. M., Geyer, H. L., Milstein, M. J., & Rosengard, J. (2022). Kaufman's Clinical Neurology for Psychiatrists - E-Book. Elsevier Health Sciences. ([details](#))

70. Koomar, S., & Blest, H. (2020). Using EdTech to Support Effective Data Monitoring: A Curated Resource List. EdTech Hub. <https://docs.edtechhub.org/lib/FS4CMYUB> ([details](#))

Gustafsson-Wright, E., Hadani, H. S., Hirsh-Pasek, K., Jalbout, M., King, E. M., ODonoghue, J. L., Olsen, B., Shapiro, J., Vegas, E., & Winthrop, R. (2022). Global education trends and research to follow in 2022. <https://policycommons.net/artifacts/4142385/global-education-trends-and-research-to-follow-in-2022/4951073/> ([details](#))

Gustafsson-Wright, E., Osborne, S., & Shankar, A. (2022). From Evidence to Scale: Lessons Learned from the Quality Education India Development Impact Bond. Center for Universal Education at The Brookings Institution. <https://eric.ed.gov/?id=ED626233> ([details](#))

71. Zhao, J., Yuping, W., Maideen, I., Moe, Z. K., & Nasirudeen, A. M. A. (2018). The Relationship between Smartphone Use and Academic Performance in a Sample of Tertiary Students in Singapore: A Cross-Sectional Study. Journal of Educational Technology, 14(4), 28–35. <https://eric.ed.gov/?id=EJ1179530> ([details](#))

72. Gustafsson-Wright, E., Osborne, S., & Aggarwal, M. (2022). Digital tools for real-time data collection in education. <https://policycommons.net/artifacts/4142237/digital-tools-for-real-time-data-collection-in-education/4951284/> ([details](#))

73. Tomkinson, E. (2016). Does Outcomes-Based Reporting Contribute to or Contradict the Realisation of Social Outcomes? In J. Butcher & D. Gilchrist, The Three Sector Solution: Delivering public policy in collaboration with not-for-profits and business (p. 185). ANU Press. <https://press-files.anu.edu.au/downloads/press/n1949/pdf/ch09.pdf> ([details](#))

74. Arias, O., Evans, D. K., & Santos, I. (2019). The skills balancing act in Sub-Saharan Africa: Investing in skills for produc-

tivity, inclusivity, and adaptability. World Bank Publications. <https://policycommons.net/artifacts/1286108/the-skills-balancing-act-in-sub-saharan-africa/1883972/> ([details](#))

75. Picciano, A. G. (2012). The evolution of big data and learning analytics in American higher education. Journal of Asynchronous Learning Networks, 16(3), 9–20. <https://eric.ed.gov/?id=EJ982669> ([details](#))

Penuel, W. R., & Gallagher, D. J. (2017). Creating Research Practice Partnerships in Education. ERIC. <https://eric.ed.gov/?id=ED573803> ([details](#))

Ramalingam, B., Barnett, I., Levy, A., Oppenheimer, C., Valters, C., Whittle, D., & Wild, L. (2017). Bridging Real-Time Data and Adaptive Management. USAID.

76. Gustafsson-Wright, E., Osborne, S., & Massey, M. (2020). Do impact bonds affect the ecosystem of social services delivery and financing? <https://policycommons.net/artifacts/4141410/do-impact-bonds-affect-the-ecosystem-of-social-services-delivery-and-financing/4949753/> ([details](#))

77. Piper, B., Destefano, J., Kinyanjui, E. M., & Ong'ele, S. (2018). Scaling up successfully: Lessons from Kenya's Tusome national literacy program. Journal of Educational Change, 19(3), 293–321. <https://doi.org/10.1007/s10833-018-9325-4> ([details](#))

78. Group, W. B. (2014). The World Bank Group A to Z 2015. World Bank Publications. ([details](#))

79. USAID (2018). Discussion Note: Adaptive Management. <https://usaidlearninglab.org/library/discussion-note-adaptive-management>

80. Gustafsson-Wright, E., Osborne, S., & Aggarwal, M. (2022, November 2). Digital tools for real-time data collection in education. Brookings. <https://policycommons.net/artifacts/4142237/digital-tools-for-real-time-data-collection-in-education/4951284/> ([details](#))

81. Evgeniou, T., Hardoon, D. R., & Ovchinnikov, A. (2020, August 13). What Happens When AI is Used to Set Grades? Harvard Business Review, 13. <https://hbr.org/2020/08/what-happens-when-ai-is-used-to-set-grades> ([details](#))

82. Hinds, D. 2019. "Realizing the Potential of Technology in Education: A Strategy for Education Providers and the Technology Industry." Accessed through <https://www.semanticscholar.org/paper/Realising-the-potential-of-technology-in-education%3A-Hinds/d6c979294f-1cd41f294508abc694a91ba9732a60>

83. Trust, T., Krutka, D. G., & Carpenter, J. P. (2016). "Together we are better": Professional learning networks for teachers. *Computers & Education*, 102, 15–34. <https://doi.org/10.1016/j.compedu.2016.06.007> (details)
84. Cilliers, J., Fleisch, B., Kotze, J., Mohohlwanex, N., Taylor, S., & Thulare, T. (2020). Can Virtual Replace In-person Coaching? Experimental Evidence on Teacher Professional Development and Student Learning in South Africa. <https://riseprogramme.org/sites/default/files/inline-files/Virtual%20vs%20InPerson%20Coaching%20Working%20Paper.pdf> (details)
85. Hassinen, S. (2023). Guidelines, recommendations and tool for non-formal learning methods. *Quaderni Di Comunità: Persone, Educazione e Welfare Nella Società 5.0: 1*, 2023, 273–284. <https://www.torrossa.com/gs/resource-Proxy?an=5521735&publisher=F35884> (details)
86. Kucirkova, N. I., Campbell, J., & Cermakova, A. L. (2023). EdTech Impact Evaluation Frameworks: Summary 2023. WikIT. [https://static1.squarespace.com/static/62fc80ec4c86a26330d18835/t/651aafa-362c10a6513e376b3/1696247723463/EdTech+Impact+Evaluation+Frameworks\\_WiKIT+2023.pdf](https://static1.squarespace.com/static/62fc80ec4c86a26330d18835/t/651aafa-362c10a6513e376b3/1696247723463/EdTech+Impact+Evaluation+Frameworks_WiKIT+2023.pdf) (details)
87. <https://www.brighteyevc.com/post/the-evolution-of-ed-tech-activity-in-private-and-public-markets>
88. <https://www.brighteyevc.com/post/the-evolution-of-ed-tech-activity-in-private-and-public-markets>
89. Jordan, K., David, R., Phillips, T., & Pellini, A. (2021). Education during the COVID-19: crisis Opportunities and constraints of using EdTech in low-income countries. *Revista de Educación a Distancia (RED)*, 21(65). <https://doi.org/10.6018/red.453621> (details)
90. Kucirkova, N. I., Campbell, J., & Cermakova, A. L. (2023). EdTech Impact Evaluation Frameworks: Summary 2023. WikIT. [https://static1.squarespace.com/static/62fc80ec4c86a26330d18835/t/651aafa-362c10a6513e376b3/1696247723463/EdTech+Impact+Evaluation+Frameworks\\_WiKIT+2023.pdf](https://static1.squarespace.com/static/62fc80ec4c86a26330d18835/t/651aafa-362c10a6513e376b3/1696247723463/EdTech+Impact+Evaluation+Frameworks_WiKIT+2023.pdf) (details)
- Kucirkova, N., Brod, G., & Gaab, N. (2023). Applying the science of learning to EdTech evidence evaluations using the EdTech Evidence Evaluation Routine (EVER). *Npj Science of Learning*, 8(1), 35. <https://doi.org/10.1038/s41539-023-00186-7> (details)
91. Milman, A. G., Allyson Parco, Rohan Carter-Rau, Jessa Henderson, Kazumi Homma, Ani Meliksetyan, and Natalie. (2022, December 19). Going digital: How learning and employment records shape access to quality education and jobs. Brookings. <https://www.brookings.edu/research/going-digital-how-learning-and-employment-records-shape-access-to-quality-education-and-jobs/> (details)
92. European Training Foundation. (2020). Public-private partnerships for skills development: a governance perspective. Volume II, Case studies. Publications Office. <https://data.europa.eu/doi/10.2816/371790> (details)
93. Institute for Future of Work. (n.d.). Home - Institute for Future of Work. Retrieved March 1, 2024, from <https://ifow.ac.za/> (details)
94. Hinds, D. 2019. "Realizing the Potential of Technology in Education: A Strategy for Education Providers and the Technology Industry." Accessed through <https://www.semanticscholar.org/paper/Realising-the-potential-of-technology-in-education%3A-Hinds/d6c979294f-1cd41f294508abc694a91ba9732a60>
95. Aithal, P. S., & Rao, P. (2016). Green education concepts & strategies in higher education model. *International Journal of Scientific Research and Modern Education (IJSRME)*, ISSN (Online), 2455-563. Retrieved from <https://www.researchgate.net/publication/306031451>
- Broberg, N. (2023). Understanding the competencies needed for innovation in greening and digitalizing economies: Insights from existing literature. *OECD Education Working Papers*. OECD Publishing. <https://doi.org/10.5267/j.uscm.2024.5.026>
- McKenzie, M., & Benavot, A. (2024). Climate change and sustainability in science and social science secondary school curricula. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000390036>
- Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M., & Scapolo, F. (2022). Towards a green and digital future, EUR 31075 EN, Publications Office of the European Union, Luxembourg.
- OECD. (2023). OECD Skills Outlook 2023: Skills for a resilient green and digital transition. OECD Publishing. <https://doi.org/10.1787/27452f29-en>
- Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu. Publications Office of the European Union. <https://op.europa.eu/en/publication-detail/-/publication/fcc33b68-d581-11e7-a5b9-01aa75ed71a1/language-en>
- Sabarwal, S., Venegas Marin, S., Spivack, M., & Ambasz, D. (2024). Learning to propel climate action. World Bank. Retrieved from <http://creativecommons.org/licenses/by/3.0/igo>

Staring, F., & Schleicher, A. (2023). Education and Innovation for the Digital and Green Transitions: How Higher Education Can Support Teachers and School Leaders. OECD Education Policy Perspectives. No. 82. OECD Publishing.

Sukumar, R. (2019). Green technology in education and sustainable development. *Journal of Emerging Technologies and Innovative Research (JETIR)*. Retrieved from <https://www.jetir.org/papers/JETIREW06022.pdf>

UNESCO. (2024a). Greening curriculum guidance: Teaching and learning for climate action. UNESCO. <https://doi.org/10.54675/AOOZ1758>

UNESCO. (2024b). Green school quality standard: Greening every learning environment. Retrieved from <https://www.unesco.org/en/articles/green-school-quality-standard-greening-every-learning-environment>

World Bank (2023). Green digital transformation: How to sustainably close the digital divide and harness digital tools for climate action. Climate Change and Development Series. Washington, DC: World Bank. Retrieved from <http://hdl.handle.net/10986/40653>

96. Kucirkova, N., Brod, G., & Gaab, N. (2023). Applying the science of learning to EdTech evidence evaluations using the EdTech Evidence Evaluation Routine (EVER). *Npj Science of Learning*, 8(1), 35. <https://doi.org/10.1038/s41539-023-00186-7>. (details)

Frau-Meigs, D., & Hibbard, L. (2016). Education 3.0 and Internet Governance: A new global alliance for children and young people's sustainable digital development. [https://www.cigionline.org/sites/default/files/gcig\\_no27web\\_0.pdf](https://www.cigionline.org/sites/default/files/gcig_no27web_0.pdf) (details)

97. Power, T., Gater, R., Grant, C., & Winters, N. (2014). Educational Technology Topic Guide. Health and Education Advice Resource Team. <http://oro.open.ac.uk/41070/> (details)

98. Hollow, D., Muyoya, C., & Brugha, M. (2016). Education Technology Map: Guidance Document. Jigsaw Consult. (details)

99. Olsen, B. (2023). Government Decision-Making on Education in Low- and Middle-Income Countries: Understanding the Fit among Innovation, Scaling Strategy, and Broader Environment. <https://www.brookings.edu/wp-content/uploads/2023/08/Olsen-2023.pdf> (details)

100. Bernard, R. M., Borokhovski, E., Schmid, R. F., Tamim, R. M., & Abrami, P. C. (2014). A meta-analysis of blended learning and technology use in higher education: from the general to the applied. *Journal of Computing in Higher Education*,

26(1), 87–122. <https://doi.org/10.1007/s12528-013-9077-3> (details)

101. Cheung, A. C. K., & Slavin, R. E. (2013). Effects of Educational Technology Applications on Reading Outcomes for Struggling Readers: A Best-Evidence Synthesis. *Reading Research Quarterly*, 48(3), 277–299. <https://doi.org/10.1002/rrq.50> (details)

102. Cheung, A. C. K., & Slavin, R. E. (2013). Effects of Educational Technology Applications on Reading Outcomes for Struggling Readers: A Best-Evidence Synthesis. *Reading Research Quarterly*, 48(3), 277–299. <https://doi.org/10.1002/rrq.50> (details)

103. Sosa, G. W., Berger, D. E., Saw, A. T., & Mary, J. C. (2011). Effectiveness of Computer-Assisted Instruction in Statistics: A Meta-Analysis. *Review of Educational Research*, 81(1), 97–128. <https://doi.org/10.3102/0034654310378174> (details); cited in: Bernard, R., Borokhovski, E., Schmid, R., & Tamim, R. (2018). Gauging the Effectiveness of Educational Technology Integration in Education: What the Best-Quality Meta-Analyses Tell Us. In *Learning, design, and technology* (pp. 1–25). [https://doi.org/10.1007/978-3-319-17727-4\\_109-2](https://doi.org/10.1007/978-3-319-17727-4_109-2) (details)

104. Takacs, Z. K., Swart, E. K., & Bus, A. G. (2015). Benefits and Pitfalls of Multimedia and Interactive Features in Technology-Enhanced Storybooks: A Meta-Analysis. *Review of Educational Research*, 85(4), 698–739. <https://doi.org/10.3102/0034654314566989> (details)

105. Cheung, A. C. K., & Slavin, R. E. (2013). Effects of Educational Technology Applications on Reading Outcomes for Struggling Readers: A Best-Evidence Synthesis. *Reading Research Quarterly*, 48(3), 277–299. <https://doi.org/10.1002/rrq.50> (details)

106. Bernard, R. M., Borokhovski, E., Schmid, R. F., Tamim, R. M., & Abrami, P. C. (2014). A meta-analysis of blended learning and technology use in higher education: from the general to the applied. *Journal of Computing in Higher Education*, 26(1), 87–122. <https://doi.org/10.1007/s12528-013-9077-3> (details)

Cheung, A. C. K., & Slavin, R. E. (2013). Effects of Educational Technology Applications on Reading Outcomes for Struggling Readers: A Best-Evidence Synthesis. *Reading Research Quarterly*, 48(3), 277–299. <https://doi.org/10.1002/rrq.50> (details)

Takacs, Z. K., Swart, E. K., & Bus, A. G. (2015). Benefits and Pitfalls of Multimedia and Interactive Features in Technology-Enhanced Storybooks: A Meta-Analysis. *Review of Educational Research*, 85(4), 698–739. <https://doi.org/10.3102/0034654314566989> (details)

107. Vegas, E., Ziegler, L., & Zerbino, N. (2019, November 20). How ed-tech can help leapfrog progress in education. Center for Universal Education at The Brookings Institution. <https://eric.ed.gov/?id=ED602936> (details)
108. Power, T., Gater, R., Grant, C., & Winters, N. (2014). Educational Technology Topic Guide. Health and Education Advice Resource Team. <http://oro.open.ac.uk/41070/> (details)  
  
Rodriguez-Segura, D. (2020). EdTech in Developing Countries: A Review of the Evidence. World Bank Research Observer, 37(2), 171–203. <https://doi.org/10.1093/wbro/lkab011> (details)  
  
Escueta, M., Quan, V., Nickow, A. J., & Oreopoulos, P. (2017). Education Technology: An Evidence-Based Review (w23744; p. w23744). National Bureau of Economic Research. <https://doi.org/10.3386/w23744> (details)
109. Unwin, T., Naseem, A., Pawluczuk, A., Shareef, M., Spiesberger, P., West, P., & Yoo, C. (2020). Education for the most marginalised post-COVID-19: Guidance for governments on the use of digital technologies in education – Act one. UNESCO, UniTwin, EdTech Hub. (details)
110. UNESCO. (2015). Education 2030: Incheon Declaration and Framework for Action Towards inclusive and equitable quality education and lifelong learning for all. UNESCO IITE. <https://iite.unesco.org/publications/education-2030-incheon-declaration-framework-action-towards-inclusive-equitable-quality-education-lifelong-learning/> (details)
111. Unwin, T., Naseem, A., Pawluczuk, A., Shareef, M., Spiesberger, P., West, P., & Yoo, C. (2020). Education for the most marginalised post-COVID-19: Guidance for governments on the use of digital technologies in education – Act one. UNESCO, UniTwin, EdTech Hub. (details)
112. Adam, T. (2022). Digital Literacy Needs for Online Learning Among Peri-Urban, Marginalised Youth in South Africa. International Journal of Mobile and Blended Learning (IJMBL), 14(3), 1–19. <https://doi.org/10.4018/IJMBL.310940>. (details) Available under Access limited to members.
113. A4AI. (2022). Meaningful Connectivity — unlocking the full power of internet access. Alliance for Affordable Internet. <https://a4ai.org/meaningful-connectivity/> (details)
114. Warschauer, M. (2003). Technology and social inclusion: rethinking the digital divide. MIT Press. (details)
115. Conklin, K., & Pellicer-Sánchez, A. (2016). Using eye-tracking in applied linguistics and second language research. Second Language Research, 32(3), 453–467. <https://doi.org/10.1177/0267658316637401> (details)
- Wolf, R., Cook, M., Reid, A., Neitzel, A., Ross, S., & Risman, K. (2021). An Evaluation of the Literacy-Infused Science Using Technology Innovation Opportunity (LISTO) i3 Evaluation (Valid 45) Final Report. Grantee Submission. <https://eric.ed.gov/?id=ED613901> (details)
116. Adil, F., Nazir, R., & Akhtar, M. (2021). Investigating the Impact on Learning Outcomes Through the Use of EdTech During Covid-19: Evidence from an RCT in the Punjab province of Pakistan. EdTech Hub. (details)  
  
Hodor, R., Owusu, E. A., Ofori-Davis, L., Afram, A., & Sefa-Nyarko, C. (2021). Voices and Evidence from End-Users of the GLTV and GLRRP Remote Learning Programme in Ghana: Insights for inclusive policy and programming. EdTech Hub. (details)  
  
Islam, T., Hussain, M., Shimul, S. N., Rupok, R. I., & Orthy, S. R. K. (2021). Integration of Technology in Education for Marginalised Children in an Urban Slum of Dhaka City During the Covid-19 Pandemic. EdTech Hub. (details)  
  
Tembey, L., Baier, J., Ogolla, C., & Mohan, P. (2021). Understanding Barriers to Girls' Access and Use of EdTech in Kenya During Covid-19. EdTech Hub. (details)
117. Rohs, M., & Ganz, M. (2015). MOOCs and the claim of education for all: A disillusion by empirical data. International Review of Research in Open and Distance Learning, 16(6). <https://doi.org/10.19173/irrodl.v16i6.2033>. (details) Available under Copyright International Review of Research in Open and Distance Learning Nov 2015.
118. Adam, T. (2022). Digital Literacy Needs for Online Learning Among Peri-Urban, Marginalised Youth in South Africa. International Journal of Mobile and Blended Learning (IJMBL), 14(3), 1–19. <https://doi.org/10.4018/IJMBL.310940>. (details) Available under Access limited to members.
119. Adam, T. (2020). Addressing Injustices through MOOCs: A study among peri-urban, marginalised, South African youth [Thesis, University of Cambridge]. <https://doi.org/10.17863/CAM.56608>. (details) Available under Attribution-Non-Commercial-ShareAlike 4.0 International.
120. McBurnie, C., Adam, T., Kaye, T., & Haßler, B. (2020). Zero-Rating Educational Content in Low- and Middle-Income Countries. EdTech Hub. (details)
121. Adil, F., Nazir, R., & Akhtar, M. (2021). Investigating the Impact on Learning Outcomes Through the Use of EdTech During Covid-19: Evidence from an RCT in the Punjab province of Pakistan. EdTech Hub. (details)



- Nicolai, S., Jefferies, K., & Lockhart, A. S. (2022). EdTech Evidence From Covid-19 Response: A thematic review of primary research from Bangladesh, Ghana, Kenya, Pakistan and Sierra Leone. EdTech Hub. ([details](#))
122. Coflan, C. M., & Kaye, T. (2020). Using education technology to support learners with special educational needs and disabilities in low- and middle-income countries. Zenodo. ([details](#))
- Lynch, P., Singal, N., & Francis, G. A. (2022). Educational technology for learners with disabilities in primary school settings in low- and middle-income countries: a systematic literature review. Educational Review, 0(0), 1–27. <https://doi.org/10.1080/00131911.2022.2035685> ([details](#))
123. Lynch, P., Singal, N., & Francis, G. A. (2022). Educational technology for learners with disabilities in primary school settings in low- and middle-income countries: a systematic literature review. Educational Review, 0(0), 1–27. <https://doi.org/10.1080/00131911.2022.2035685> ([details](#))
124. Lynch, P., Singal, N., & Francis, G. A. (2022). Educational technology for learners with disabilities in primary school settings in low- and middle-income countries: a systematic literature review. Educational Review, 0(0), 1–27. <https://doi.org/10.1080/00131911.2022.2035685> ([details](#))
125. Hersh, M., & Mouroutsou, S. (2019). Learning technology and disability—Overcoming barriers to inclusion: Evidence from a multicountry study. British Journal of Educational Technology, 50(6), 3329–3344. <https://doi.org/10.1111/bjet.12737> ([details](#))
126. Lynch, P., Singal, N., & Francis, G. A. (2022). Educational technology for learners with disabilities in primary school settings in low- and middle-income countries: a systematic literature review. Educational Review, 0(0), 1–27. <https://doi.org/10.1080/00131911.2022.2035685> ([details](#))
127. World Bank. (2021). A Landscape Review of ICT for Disability-Inclusive Education. <https://openknowledge.worldbank.org/server/api/core/bitstreams/ef7fd554-8359-50f9-9718-7161545dbc54/content> ([details](#))
128. Ashlee, A., Clericetti, G., & Mitchell, J. (2020). Refugee Education: A Rapid Evidence Review. EdTech Hub. ([details](#))
- Islam, A., Wang, L. C., & Hassan, H. (2022). Delivering Remote Learning Using a Low-Tech Solution: Evidence from an RCT during the Covid-19 Pandemic. EdTech Hub. ([details](#))
- Dahya, N. (2016). Education in Conflict and Crisis: How Can Technology Make a Difference? A Landscape Review. GIZ. <https://www.eccnetwork.net/sites/default/files/media/file/GIZ%20InDesign-Vorlage%20fu%CC%88r%20Publikationen%20%E2%80%93%20DIN%20A4%20hoch.pdf> ([details](#))
- Mitchell, J., Ashlee, A., Clericetti, G., Gladwell, J., & Torrance, R. (2020). Education in Emergencies: A Rapid Evidence Review. EdTech Hub. ([details](#))
- USAID. (2020). Delivering Distance Learning in Emergencies. <https://www.edu-links.org/sites/default/files/media/file/DELIVERING%20DISTANCE%20LEARNING%20IN%20EMERGENCIES.pdf> ([details](#))
129. Oded, Y. (2019) University of the People: changing the world, one student at a time. In Fair Planet.org <https://www.fairplanet.org/story/university-of-the-people-changing-the-world-one-student-at-a-time/>
- Kalman, Y. M. (2010). How Low Can You Go? The Tuition-Free Business Model of the University of the People. In Chais conference on instructional technologies research, Ra'anana, Israel.
130. World Bank, Bill and Melinda Gates Foundation, FCDO, UNESCO, UNICEF, & USAID. (2022). Guide for Learning Recovery and Acceleration: Using the RAPID Framework to Address COVID-19 Learning Losses and Build Forward Better. <https://thedocs.worldbank.org/en/doc/e52f55322528903b27f1b7e61238e416-0200022022/related/Guide-for-Learning-Recovery-and-Acceleration-06-23.pdf> ([details](#))
- Yaniawati, R. P., Kartasasmita, B. G., Kariadinata, R., & Sari, E. (2017). Accelerated learning method using edmodo to increase students' mathematical connection and self-regulated learning. Proceedings of the 2017 International Conference on Education and Multimedia Technology- ICENT '17, 53–57. <https://doi.org/10.1145/3124116.3124128> ([details](#))
131. Akbiyik, C., & Şimsek, N. (2009). Accelerated Learning in Classroom and Computer Environments. 21. ([details](#))
132. Damani, K. (2020). Accelerated Learning and EdTech: A Rapid Evidence Review. EdTech Hub. ([details](#))
133. Damani, K. (2020). Accelerated Learning and EdTech: A Rapid Evidence Review. EdTech Hub. ([details](#))
134. Damani, K., & Mitchell, J. (2020). Radio: A Rapid Evidence Review. EdTech Hub. ([details](#))
135. McBurnie, C. (2020). Using Interactive Radio Instruction to Mitigate the Educational Impact of Covid-19: A curated resource list. EdTech Hub. ([details](#))

136. Hodor, R., Owusu, E. A., Ofori-Davis, L., Afram, A., & Sefa-Nyarko, C. (2021). Voices and Evidence from End-Users of the GLTV and GLRRP Remote Learning Programme in Ghana: Insights for inclusive policy and programming. EdTech Hub. [\(details\)](#)
137. Burde, D., Guven, O., Kelcey, J., Lahmann, H., & Al-Abbadi, K. (2015). What Works to Promote Children's Educational Access, Quality of Learning, and Wellbeing in Crisis-Affected Contexts. 93. [\(details\)](#)
138. Lamba, K., & Reimers, F. (2020). Sierra Leone and Liberia: Rising Academy Network on air (Education Continuity during the Coronavirus Crisis). World Bank; OECD; Harvard Global Education Innovation Initiative; HundrED. [\(details\)](#)
139. Haßler, B., Megha-Bongnkar, G., Regis, C., & Blower, T. (2021). Final Report and Recommendations. Open Development & Education. [\(details\)](#)
140. Islam, A., Wang, L. C., & Hassan, H. (2022). Delivering Remote Learning Using a Low-Tech Solution: Evidence from an RCT during the Covid-19 Pandemic. EdTech Hub. [\(details\)](#)
141. Afoakwah, E., Carballo, F., Caro, A., D'Cunha, S., Dobrowski, S., & Fallon, A. (2021). Dialling up Learning: Testing the Impact of Delivering Educational Content via Interactive Voice Response to Students and Teachers in Ghana. EdTech Hub. [\(details\)](#)
142. Watson, J., & McIntyre, N. (2020). Educational Television: A Rapid Evidence Review. EdTech Hub. [\(details\)](#)
143. Borzekowski, D. L. G., Singpurwalla, D., Mehrotra, D., & Howard, D. (2019). The impact of Galli Galli Sim Sim on Indian preschoolers. *Journal of Applied Developmental Psychology*, 64, 101054. <https://doi.org/10.1016/j.appdev.2019.101054> [\(details\)](#)  
  
Moland, N. A. (2019). *Can Big Bird Fight Terrorism?: Children's Television and Globalized Multicultural Education* (Illustrated edition). Oxford University Press. [\(details\)](#)  
  
Watson, J. (2020, March 31). Learning through television in low-income contexts: mitigating the impact of coronavirus (COVID-19). EdTech Hub. <https://edtechhub.org/2020/03/31/learning-through-television-in-low-income-contexts-mitigating-the-impact-of-covid-19/> [\(details\)](#)
144. Hodor, R., Owusu, E. A., Ofori-Davis, L., Afram, A., & Sefa-Nyarko, C. (2021). Voices and Evidence from End-Users of the GLTV and GLRRP Remote Learning Programme in Ghana: Insights for inclusive policy and programming. EdTech Hub. [\(details\)](#)
145. Jordan, K., & Mitchell, J. (2020). Messaging Apps, SMS, and Social Media: A Rapid Evidence Review. EdTech Hub. [\(details\)](#)
146. Angrist, N., Bergman, P., Brewster, C., & Matsheng, M. (2020). Stemming Learning Loss During the Pandemic: A Rapid Randomized Trial of a Low-Tech Intervention in Botswana (SSRN Scholarly Paper 3663098). <https://doi.org/10.2139/ssrn.3663098> [\(details\)](#)  
  
Jordan, K., & Mitchell, J. (2020). Messaging Apps, SMS, and Social Media: A Rapid Evidence Review. EdTech Hub. [\(details\)](#)  
  
Pouzevara, S., & King, S. (2014). MobilLiteracy-Uganda program phase 1: Endline report. RTI International. [https://ierc-publicfiles.s3.amazonaws.com/public/resources/MobilLiteracy\\_Endline\\_Report\\_final\\_Rev\\_SUBMITTED\\_Jan%206%202014%281%29.pdf](https://ierc-publicfiles.s3.amazonaws.com/public/resources/MobilLiteracy_Endline_Report_final_Rev_SUBMITTED_Jan%206%202014%281%29.pdf) [\(details\)](#)
147. Butgereit, L., Leonard, B., Le Roux, C., Rama, H., De Sousa, M., & Naidoo, T. (2010). Dr Math gets MUDDY: the "dirt" on how to attract teenagers to Mathematics and Science by using multi-user dungeon games over Mxit on cell phones. The authors. <https://researchspace.csir.co.za/dspace/handle/10204/4085> [\(details\)](#)
148. Budree, A., & Hendriks, T. (2019). Instant Messaging Tutoring: A Case of South Africa. 2019 9th International Conference on Cloud Computing, Data Science & Engineering (Confluence), 615–619. <https://doi.org/10.1109/CONFLUENCE.2019.8776928> [\(details\)](#)
149. Jordan, K., & Mitchell, J. (2020). Messaging Apps, SMS, and Social Media: A Rapid Evidence Review. EdTech Hub. [\(details\)](#)
150. Boujikian, M., Carter, A., & Jordan, K. (2022). The Sandbox Model: A Novel Approach to Iterating while Implementing an Emergency Education Program in Lebanon during the COVID-19 Pandemic. *Journal on Education in Emergencies*, 8(3), 215. <https://doi.org/10.33682/rj45-k7z7> [\(details\)](#)
151. Gon, S., & Rawekar, A. (2017). Effectivity of E-Learning through Whatsapp as a Teaching Learning Tool. *MVP Journal of Medical Sciences*, 19–25. <https://doi.org/10.18311/mvpjms.v4i1.8454>. [\(details\)](#) Available under Copyright (c) 2017 Array.
152. Jordan, K., & Mitchell, J. (2020). Messaging Apps, SMS, and Social Media: A Rapid Evidence Review. EdTech Hub. [\(details\)](#)  
  
Motteram, G., Dawson, S., & Al-Masri, N. (2020). WhatsApp supported language teacher development: A case study in

- the Zataari refugee camp. *Education and Information Technologies*, 25(6), 5731–5751. <https://doi.org/10.1007/s10639-020-10233-0> (details)
153. Safeguarding In Schools. (2022). Why schools shouldn't use Whatsapp - Safeguarding In Schools. <https://support.safeguardinginschools.co.uk/article/36-why-schools-shouldnt-use-whatsapp> (details)
154. The World Bank. (2018). World Development Report 2018: Learning to realize education's promise. (details)
155. Unwin, T., Naseem, A., Pawluczuk, A., Shareef, M., Spiesberger, P., West, P., & Yoo, C. (2020). Education for the most marginalised post-COVID-19: Guidance for governments on the use of digital technologies in education ACT TWO (OF THREE): FULL REPORT (p. 118). EdTech Hub, UNESCO, UniTwin. (details)
- World Bank. (2021). A Landscape Review of ICT for Disability-Inclusive Education. <https://openknowledge.worldbank.org/server/api/core/bitstreams/ef7fd554-8359-50f9-9718-7161545dbc54/content> (details)
156. IADB. (2019). The Future is Now: Transversal Skills in Latin America and the Caribbean in the 21st Century. Inter-American Development Bank. <https://publications.iadb.org/publications/english/viewer/The-Future-is-Now-Transversal-Skills-in-Latin-America-and-the-Caribbean-in-the-21st-Century.pdf> (details)
157. Yeung, K. L., Carpenter, S. K., & Corral, D. (2021). A Comprehensive Review of Educational Technology on Objective Learning Outcomes in Academic Contexts. *Educational Psychology Review*, 33(4), 1583–1630. <https://doi.org/10.1007/s10648-020-09592-4> (details)
158. Power, T., Gater, R., Grant, C., & Winters, N. (2014). Educational Technology Topic Guide. Health and Education Advice Resource Team. <http://oro.open.ac.uk/41070/> (details)
159. Bernard, R. M., Borokhovski, E., Schmid, R. F., Tamim, R. M., & Abrami, P. C. (2014). A meta-analysis of blended learning and technology use in higher education: from the general to the applied. *Journal of Computing in Higher Education*, 26(1), 87–122. <https://doi.org/10.1007/s12528-013-9077-3> (details)
160. Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). The Effectiveness of Online and Blended Learning: A Meta-Analysis of the Empirical Literature. *Teachers College Record: The Voice of Scholarship in Education*, 115(3), 1–47. <https://doi.org/10.1177/016146811311500307> (details)
161. Chi, M. T., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational psychologist*, 49(4), 219–243.
- Eugenijus, L. (2023). Integrating blended learning and STEM education: Innovative approaches to promote interdisciplinary learning. *Research and Advances in Education*, 2(9), 20–36.
- Lee, H. Y., Lin, C. J., Wang, W. S., Chang, W. C., & Huang, Y. M. (2023). Precision education via timely intervention in K-12 computer programming course to enhance programming skill and affective-domain learning objectives. *International Journal of STEM Education*, 10(1), 52.
- Wu, T. T., Lee, H. Y., Wang, W. S., Lin, C. J., & Huang, Y. M. (2023). Leveraging computer vision for adaptive learning in STEM education: Effect of engagement and self-efficacy. *International Journal of Educational Technology in Higher Education*, 20(1), 53.
162. GEEAP. (2020). Cost-Effective-Approaches-to-Improve-Global-Learning-What-Does-Recent-Evidence-Tell-Us-Are-Smart-Buys-for-Improving-Learning-in-Low-and-Middle-Income-Countries.pdf. Global Education Evidence Advisory Panel. <https://documents1.worldbank.org/curated/en/719211603835247448/pdf/Cost-Effective-Approaches-to-Improve-Global-Learning-What-Does-Recent-Evidence-Tell-Us-Are-Smart-Buys-for-Improving-Learning-in-Low-and-Middle-Income-Countries.pdf> (details)
163. Major, L., Francis, G. A., & Tsapali, M. (2021). The effectiveness of technology-supported personalised learning in low- and middle-income countries: A meta-analysis. *British Journal of Educational Technology*, 52(5), 1935–1964. <https://doi.org/10.1111/bjet.13116> (details)
164. Zheng, L., Long, M., Zhong, L., & Gyasi, J. F. (2022). The effectiveness of technology-facilitated personalized learning on learning achievements and learning perceptions: a meta-analysis. *Education and Information Technologies*, 27(8), 11807–11830. <https://doi.org/10.1007/s10639-022-11092-7> (details)
165. Sun, S., Else-Quest, N. M., Hodges, L. C., French, A. M., & Dowling, R. (2021). The Effects of ALEKS on Mathematics Learning in K-12 and Higher Education: A Meta-Analysis. *Investigations in Mathematics Learning*, 13(3), 182–196. <https://doi.org/10.1080/19477503.2021.1926194> (details)
166. Weeks, J., & Baron, P. (2021). Exploring Math Education Relations by Analyzing Large Data Sets II. Research Memorandum. ETS RM-21-02. Educational Testing Service. <https://eric.ed.gov/?id=ED617566> (details)

167. Cai, Z., Mao, P., Wang, D., He, J., Chen, X., & Fan, X. (2022). Effects of Scaffolding in Digital Game-Based Learning on Student's Achievement: a Three-Level Meta-analysis. *Educational Psychology Review*, 34(2), 537–574. <https://doi.org/10.1007/s10648-021-09655-0> (details)
168. Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, 59(2), 661–686. <https://doi.org/10.1016/j.compedu.2012.03.004> (details)

Girard, C., Ecalte, J., & Magnan, A. (2013). Serious games as new educational tools: how effective are they? A meta-analysis of recent studies: Serious games as educational tools. *Journal of Computer Assisted Learning*, 29(3), 207–219. <https://doi.org/10.1111/j.1365-2729.2012.00489.x> (details)

Riopel, M., Nenciovici, L., Potvin, P., Chastenay, P., Charland, P., Sarrasin, J. B., & Masson, S. (2019). Impact of serious games on science learning achievement compared with more conventional instruction: an overview and a meta-analysis. *Studies in Science Education*, 55(2), 169–214. <https://doi.org/10.1080/03057267.2019.1722420> (details)

Wouters, P., Nimwegen, C. van, Oostendorp, H. van, & Spek, E. D. van der. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, 105(2), 249–265. <https://doi.org/10.1037/a0031311> (details)
169. Benavides-Varela, S., Callegher, C. Z., Fagiolini, B., Leo, I., Altoè, G., & Lucangeli, D. (2020). Effectiveness of digital-based interventions for children with mathematical learning difficulties: A meta-analysis. *Computers & Education*, 157, 103953. <https://doi.org/10.1016/j.compedu.2020.103953> (details)

Byun, J., & Joung, E. (2018). Digital game-based learning for K-12 mathematics education: A meta-analysis. *School Science and Mathematics*, 118(3–4), 113–126. <https://doi.org/10.1111/ssm.12271> (details)

Ran, H., Kasli, M., & Secada, W. G. (2021). A Meta-Analysis on Computer Technology Intervention Effects on Mathematics Achievement for Low-Performing Students in K-12 Classrooms. *Journal of Educational Computing Research*, 59(1), 119–153. <https://doi.org/10.1177/0735633120952063> (details)

Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis. *Journal of Computer Assisted Learning*, 35(3), 407–420. <https://doi.org/10.1111/jcal.12347> (details)
170. Bediou, B., Adams, D. M., Mayer, R. E., Tipton, E., Green, C. S., & Bavelier, D. (2018). Meta-analysis of action video game impact on perceptual, attentional, and cognitive skills. *Psychological Bulletin*, 144(1), 77–110. <https://doi.org/10.1037/bul0000130> (details)
171. Jordan, K., & Mitchell, J. (2020). Messaging Apps, SMS, and Social Media: A Rapid Evidence Review. EdTech Hub. (details)
172. Abdullah, M., Madain, A., & Jararweh, Y. (2022). ChatGPT: Fundamentals, applications and social impacts. 2022 Ninth International Conference on Social Networks Analysis, Management and Security (SNAMS), 1–8. <https://doi.org/10.1109/SNAMS58071.2022.10062688> (details)
173. Steenbergen-Hu, S., & Cooper, H. (2013). A Meta-Analysis of the Effectiveness of Intelligent Tutoring Systems on K–12 Students' Mathematical Learning. 18. <https://doi.org/10.1037/a0032447> (details)
174. Kulik, J. A., & Fletcher, J. D. (2016). Effectiveness of Intelligent Tutoring Systems: A Meta-Analytic Review. 37. <https://doi.org/10.3102/0034654315581420> (details)
175. Xu, Z., Wijekumar, K. (Kay), Ramirez, G., Hu, X., & Irey, R. (2019). The effectiveness of intelligent tutoring systems on K-12 students' reading comprehension: A meta-analysis. *British Journal of Educational Technology*, 50(6), 3119–3137. <https://doi.org/10.1111/bjet.12758> (details)
176. Carlana, M., & Ferrara, E. (2021). Apart but Connected: Online Tutoring and Student Outcomes during the COVID-19 Pandemic (HKS Faculty Research Working Paper Series RWP21-001). <https://www.hks.harvard.edu/publications/apart-connected-online-tutoring-and-student-outcomes-during-covid-19-pandemic#citation> (details)

Arriola, M., Gortazar, L., Hupkau, C., Pillado, Z., & Roldán, T. (n.d.). A high-impact, on-line tutoring programme for disadvantaged pupils in response to Covid-19. [https://www.esade.edu/ecpol/wp-content/uploads/2021/09/AAFF\\_Menttores\\_PolicyReport\\_ENG\\_2021\\_compressed.pdf](https://www.esade.edu/ecpol/wp-content/uploads/2021/09/AAFF_Menttores_PolicyReport_ENG_2021_compressed.pdf) (details)

Gortazar, L., Hupkau, C., & Roldán-Monés, A. (2024). Online tutoring works: Experimental evidence from a program with vulnerable children. *Journal of Public Economics*, 232, 105082. <https://doi.org/10.1016/j.jpubeco.2024.105082> (details)



177. Angrist et al. 2020; ([Stemming Learning Loss During the Pandemic: A Rapid Randomized Trial of a Low-Tech Intervention in Botswana Angrist et al., 2020](#))  
  
Angrist, N., Bergman, P., & Matsheng, M. (2022). Experimental evidence on learning using low-tech when school is out. *Nature Human Behaviour*, 6(7), 941–950. <https://doi.org/10.1038/s41562-022-01381-z>. ([details](#))
178. Herrera Bohórquez, L. I., Largo Rodríguez, J. D., Viáfara González, J. J., Herrera Bohórquez, L. I., Largo Rodríguez, J. D., & Viáfara González, J. J. (2019). Online Peer-Tutoring: A Renewed Impetus for Autonomous English Learning. *How*, 26(2), 13–31. <https://doi.org/10.19183/how.26.2.503> ([details](#))
179. Tan, S. C., Chung, S. H., Cheung, Y. L., Looi, C. K., & Wong, W. H. (2020). Holistic Design of a Mobile Peer Tutoring Application based on Learning and User Needs Analysis. 673–684. <https://www.learntechlib.org/primary/p/218864/> ([details](#))
180. Wu, M., & Gao, Q. (2020). Using Live Video Streaming in Online Tutoring: Exploring Factors Affecting Social Interaction. *International Journal of Human–Computer Interaction*, 36(10), 964–977. <https://doi.org/10.1080/10447318.2019.1706288> ([details](#))
181. Youngblut, C. (1998). Educational Uses of Virtual Reality Technology. INSTITUTE FOR DEFENSE ANALYSES ALEXANDRIA VA. <https://apps.dtic.mil/sti/citations/ADA339438> ([details](#))
182. Downes, S. (2008). Places to go: Connectivism & connective knowledge. *Innovate: Journal of Online Education*, 5(1), 6. ([details](#))
183. Cormier, D. (2008). Rhizomatic Education: Community as Curriculum. *Innovate: Journal of Online Education*, 4. ([details](#))
184. Adam, T. (2020). Open educational practices of MOOC designers: embodiment and epistemic location. *Distance Education*, 41(2), 171–185. <https://doi.org/10.1080/01587919.2020.1757405> ([details](#))  
  
Farrow, R. (2017). Open education and critical pedagogy. *Learning, Media and Technology*, 42(2), 130–146. <https://doi.org/10.1080/17439884.2016.1113991> ([details](#))
185. Hennessy, S., D'Angelo, S., McIntyre, N., Koomar, S., Kreimeia, A., Cao, L., Brugh, M., & Zubairi, A. (2022). Technology Use for Teacher Professional Development in Low- and Middle-Income Countries: A systematic review. *Computers and Education Open*. <https://doi.org/10.1016/j.caeo.2022.100080> ([details](#))
186. Hennessy, S., D'Angelo, S., McIntyre, N., Koomar, S., Kreimeia, A., Cao, L., Brugh, M., & Zubairi, A. (2022). Technology Use for Teacher Professional Development in Low- and Middle-Income Countries: A systematic review. *Computers and Education Open*. <https://doi.org/10.1016/j.caeo.2022.100080> ([details](#))
187. Hennessy, S., D'Angelo, S., Koomar, S., Adam, T., Cao, L., & Haßler, B. (2023). Technology use in teacher preparation and professional development in low- and middle-income countries. *Global Education Monitoring Report*. ([details](#))
188. Power, T., McCormick, R., & Asbeek-Brusse, E. (2017). A Quasi-Experimental Study of the Classroom Practices of English Language Teachers and the English Language Proficiency of Students, in Primary and Secondary Schools in Bangladesh. <http://www.eiabd.com/publications/research-publications/qe-qd-studies.html> ([details](#))  
  
Shohel, M. M. C., & Kirkwood, A. (2012). Using technology for enhancing teaching and learning in Bangladesh: challenges and consequences. *Learning, Media and Technology*, 37(4). <https://doi.org/10.1080/17439884.2012.671177> ([details](#))
189. Golding, J., & Batiibwe, M. S. K. (2021). A Design Approach to Mathematics Teacher Educator Development in East Africa. *Journal of Research and Advances in Mathematics Education*, 6(1). <https://doi.org/10.23917/jramathedu.v6i1.11898> ([details](#))
190. Amevor, G., Bayaga, A., & Bosse, M. (2021). Analysis of Rural-Based Pre-Service Teachers Spatial-Visualisation Skills in Problem Solving in Vector Calculus Using MATLAB. *International Journal of Emerging Technologies in Learning (IJET)*, 16. <https://doi.org/10.3991/ijet.v16i10.19269> ([details](#))
191. Hennessy, S., D'Angelo, S., Koomar, S., Adam, T., Cao, L., & Haßler, B. (2023). Technology use in teacher preparation and professional development in low- and middle-income countries. *Global Education Monitoring Report*. ([details](#))
192. Wang, Q., Chen, B., Fan, Y., & Zhang, G. (2018). MOOCs as an alternative for teacher professional development: examining learner persistence in one Chinese MOOC. *Peking University*. ([details](#))
193. Wolfenden, F., Cross, S., & Henry, F. (2017). MOOC adaptation and translation to improve equity in participation. *Journal of Learning for Development*, 4(2), 127–142. <https://doi.org/10.56059/jl4d.v4i2.209> ([details](#))
194. Oyo, B., Kalema, B. M., & Byabazaire, J. (2017). MOOCs for in-service teachers: the case of Uganda and lessons for Africa. *Revista Española de Pedagogía*, 75(266). <https://doi.org/10.22550/rep75-1-2017-07> ([details](#))

195. Kennedy, E., & Laurillard, D. (2019). The potential of MOOCs for large-scale teacher professional development in contexts of mass displacement. *London Review of Education*, 17(2), 141–158. <https://doi.org/10.18546/lre.17.2.04> (details)
196. Castillo, N. M., Lee, J., Zahra, F. T., & Wagner, D. A. (2015). MOOCs for development: trends, challenges, and opportunities. *Information Technologies & International Development*, 11(2). (details)  
  
Liyanagunawardena, T., Williams, S., & Adams, A. (2013). The impact and reach of MOOCs: A developing countries' perspective. *E-Learning Papers*, 33, 38–46. (details)
197. Inter-Agency Network for Education in Emergencies. (2022). Promising Practices in Teacher Professional Development (Teachers in Crisis Context). (details)
198. Onguko, B. B. (2014). JiFUNzeni: a blended learning approach for sustainable teachers' professional development. *The Electronic Journal of E-Learning*, 12(1). (details)
199. Han, H., & Røkenes, F. M. (2020). Flipped Classroom in Teacher Education: A Scoping Review. *Frontiers in Education*, 5. <https://doi.org/10.3389/feduc.2020.601593> (details)
200. El-Serafy, Y., Adam, T., & Haßler, B. (2022). The effectiveness of technology-supported teacher professional learning communities in emergency settings. *Future-Proofing Teacher Education: Voices from South Africa and Beyond*. In S. Gravett & N. Petersen (Eds.), *Future-Proofing Teacher Education: Voices from South Africa and Beyond* (1st ed.). Routledge. <https://doi.org/10.4324/9781003185499> (details)  
  
Hennessy, S., D'Angelo, S., Koomar, S., Adam, T., Cao, L., & Haßler, B. (2023). Technology use in teacher preparation and professional development in low- and middle-income countries. *Global Education Monitoring Report*. (details)
201. Pota, V., Hennessy, S., Koomar, S., Kreimeia, A., Zubairi, A., Aerts, C., & Gault, C. (2021). Turning to technology: A global survey of teachers' responses to the Covid-19 pandemic. *T4 Education & EdTech Hub*. (details)
202. Manca, S., & Ranieri, M. (2013). Is it a tool suitable for learning? A critical review of the literature on Facebook as a technology-enhanced learning environment. *Journal of Computer Assisted Learning*, 29(6). <https://doi.org/10.1111/jcal.12007> (details)
203. Habibi, A., Mukinin, A., Riyanto, Y., Prasohjo, L. D., Sulistiyo, U., Sofwan, M., & Saudagar, F. (2018). Building an online community: student teachers' perceptions on the advantages of using social networking services in a teacher education program. *Turkish Online Journal of Distance Education*, 19(1). <https://doi.org/10.17718/tojde.382663> (details)
204. Bett, H., & Makewa, L. (2020). Can Facebook groups enhance continuing professional development of teachers? Lessons from Kenya. *Asia-Pacific Journal of Teacher Education*, 48(2). <https://doi.org/10.1080/1359866x.2018.1542662> (details)
205. Stewart, B. L. (2015). Cultivating a Personal Learning Network that Leads to Professional Change. (details)
206. Sunday, A. A. (2021). Use of Twitter Technology in Educational Learning. *The Turkish Online Journal of Educational Technology*, 20(2). (details)
207. Ramazanoğlu, M., & Toytok, E. H. (2021). An Investigation of pre-service teachers' motives for using Instagram: Pre-service teachers' motives for using Instagram. *International Journal of Curriculum and Instruction*, 13(1). (details)
208. Spiro, J. (2011). Guided interaction as intercultural learning: designing internationalisation into a mixed delivery teacher education programme. *Higher Education Research & Development*, 30(5). <https://doi.org/10.1080/07294360.2011.598453> (details)  
  
Üzüm, B., Akayoglu, S., & Yazan, B. (2020). Using telecollaboration to promote intercultural competence in teacher training classrooms in Turkey and the USA. *ReCALL*, 32(2). <https://doi.org/10.1017/S0958344019000235> (details)
209. Moodley, M. (2019). WhatsApp: Creating a virtual teacher community for supporting and monitoring after a professional development programme. *South African Journal of Education*, 39(2). <https://doi.org/10.15700/saje.v39n2a1323> (details)
210. Nedungadi, P., Mulki, K., & Raman, R. (2018). Improving educational outcomes & reducing absenteeism at remote villages with mobile technology and WhatsApp: findings from rural India. *Education and Information Technologies*, 23(1), 113–127. <https://doi.org/10.1007/s10639-017-9588-z> (details)
211. Habibi, A., Mukinin, A., Riyanto, Y., Prasohjo, L. D., Sulistiyo, U., Sofwan, M., & Saudagar, F. (2018). Building an online community: student teachers' perceptions on the advantages of using social networking services in a teacher education program. *Turkish Online Journal of Distance Education*, 19(1). <https://doi.org/10.17718/tojde.382663> (details)
212. Cilliers, J., Fleisch, B., Kotze, J., Mohohlwanex, N., Taylor, S., & Thulare, T. (2020). Can Virtual Replace In-person Coaching? Experimental Evidence on Teacher Profes-

- pional Development and Student Learning in South Africa.
- <https://riseprogramme.org/sites/default/files/inline-files/Virtual%20vs%20InPerson%20Coaching%20Working%20Paper.pdf>
- (details)
- Kotze, J., Taylor, S., & Fleisch, B. (2018). Moving towards cost-effective delivery models of teacher coaching: evidence from field experiments in South Africa. (details)
213. Bagby, E., Swift-Morgan, J., Niang, A., & Upadhyay, A. (2022). Achieving Cost-Effective Instructional Coaching at Scale: Evidence from Senegal. Chemonics International. (details)
214. Bruns, B., Costa, L., & Cunha, N. (2018). Through the looking glass: can classroom observation and coaching improve teacher performance in Brazil? *Economics of Education Review*, 64, 214–250. <https://doi.org/10.1016/j.econedurev.2018.03.003> (details)
215. Jukes, M. C., Turner, E. L., Dubeck, M. M., Halliday, K. E., Inyega, H. N., Wolf, S., Zuilkowski, S. S., & Brooker, S. J. (2017). Improving literacy instruction in Kenya through teacher professional development and text messages support: a cluster randomized trial. *Journal of Research on Educational Effectiveness*, 10(3). <https://doi.org/10.1080/19345747.2016.1221487> (details)
216. Slade, T. S., Kipp, S., Cummings, S., Nyirongo, K., & Pouezevara, S. (2018). Short message service (SMS)–based remote support and teacher retention of training gains in Malawi. In *Cultivating dynamic educators: case studies in teacher behavior change in Africa and Asia* (pp. 131–167). RTI Press. (details)
217. Hennessy, S., D'Angelo, S., Koomar, S., Adam, T., Cao, L., & Haßler, B. (2023). Technology use in teacher preparation and professional development in low- and middle-income countries. *Global Education Monitoring Report*. (details)
218. Piper, B., Oyanga, A., Mejia, J., & Pouezevara, S. (2017). Implementing large-scale instructional technology in Kenya: Changing instructional practice and developing accountability in a National Education System. *International Journal of Education and Development Using ICT*, 13(3). (details)
219. Pouezevara, S., Brunette, T., Jordan, R., & Nakyejwe, D. (2019). Uganda Impact Study Report. RTI International. (details)
220. VVOB. (2021). Teacher motivation for online learning: piloting a microlearning support system | VVOB in Rwanda. VVOB. <https://rwanda.vvob.org/news/teacher-motivation-online-learning-piloting-microlearning-support-system> (details)
221. Haßler, B., Hennessy, S., & Hofmann, R. (2018). Sustaining and Scaling Pedagogic Innovation in Sub-Saharan Africa: Grounded Insights For Teacher Professional Development. *Journal of Learning for Development*, 5(1). <https://doi.org/10.56059/jl4d.v5i1.264> (details)
222. Batman, D., & Saka, A. Z. (2021). The Effects of Micro-Reflective Teaching Practices on the Professional Skill Development of Pre-Service Physics Teachers. *The Turkish Online Journal of Educational Technology*, 20(4). (details)
223. Lok, L., Schellings, G., Brouwer, N., & Brok, P. D. (2018). Investigating effects of using digital video in teacher training in Cambodia. *Journal of Technology and Teacher Education*, 26(2). (details)
224. Inter-Agency Network for Education in Emergencies. (2022). Promising Practices in Teacher Professional Development (Teachers in Crisis Context). (details)
225. Inter-Agency Network for Education in Emergencies. (2022). Promising Practices in Teacher Professional Development (Teachers in Crisis Context). (details)
226. Fernández-Batanero, J.-M., Román-Graván, P., Reyes-Rebollo, M.-M., & Montenegro-Rueda, M. (2021). Impact of Educational Technology on Teacher Stress and Anxiety: A Literature Review. *International Journal of Environmental Research and Public Health*, 18(2), 548. <https://doi.org/10.3390/ijerph18020548>. (details) Available under <http://creativecommons.org/licenses/by/3.0/>.
227. Mitchell, J., & D'Rozario, J. (2022). Cost-Effective EdTech Paper 1: A position piece on how the sector can make progress. EdTech Hub. <https://docs.edtechhub.org/lib/RPR-47JXT> (details)
228. GEEAP. (2020). Cost-Effective-Approaches-to-Improve-Global-Learning-What-Does-Recent-Evidence-Tell-Us-Are-Smart-Buys-for-Improving-Learning-in-Low-and-Middle-Income-Countries.pdf. Global Education Evidence Advisory Panel. <https://documents1.worldbank.org/curated/en/719211603835247448/pdf/Cost-Effective-Approaches-to-Improve-Global-Learning-What-Does-Recent-Evidence-Tell-Us-Are-Smart-Buys-for-Improving-Learning-in-Low-and-Middle-Income-Countries.pdf> (details)
229. Allende, C., Gallego, F., & Nielson, C. (2019). Approximating the Equilibrium Effects of Informed School Choice. (details)
230. IPA. (2016, May 4). The Impact of Information Provision on Human Capital Accumulation and Child Labor in Peru. Innovations for Poverty Action. <https://www.poverty-action.org/study/information-about-returns-post-primary-education-peru> (details)

231. Watson, J., & McIntyre, N. (2020). Educational Television: A Rapid Evidence Review. EdTech Hub. ([details](#))
232. Wolff, L., Castro, C. de M., Navarro, J. C., & García, N. (2002). EDUCATION: EXPERIENCE OF MEXICO AND BRAZIL. Technologies for Education: Potentials, Parameters and Prospects, 144–152. [http://woulibrary.wou.edu/my/weko/eed502/Chapter\\_10\\_Technologies\\_for\\_education.pdf](http://woulibrary.wou.edu/my/weko/eed502/Chapter_10_Technologies_for_education.pdf) ([details](#))
233. Batada, A., Banarjee, S., & Subramanian, M. (2016). Opening new doors: Community engagement in India. In C. F. Cole & J. H. Lee (Eds.), *The Sesame Effect: The Global Impact of the Longest Street in the World*. Routledge. ([details](#))
234. Watson, J., Hennessy, S., & Vignoles, A. (2020). The relationship between educational television and mathematics capability in Tanzania. *British Journal of Educational Technology*, 52(2). <https://doi.org/10.1111/bjet.13047> ([details](#))
235. Watson, J., & McIntyre, N. (2020). Educational Television: A Rapid Evidence Review. EdTech Hub. ([details](#))
236. McGreal, R. (2019). A survey of OER implementations in 13 higher education institutions. *The International Review of Research in Open and Distributed Learning*, 20(5), 141–145. <https://doi.org/10.19173/irrodl.v20i5.4577> ([details](#))
237. Blomgren, C. (2018). OER Awareness and Use: The Affinity Between Higher Education and K-12. *The International Review of Research in Open and Distributed Learning*, 19(2). <https://doi.org/10.19173/irrodl.v19i2.3431> ([details](#))
238. Kabugo, D. (2020). Utilizing Open Education Resources to Enhance Students' Learning Outcomes during the COVID-19 Schools Lockdown: A Case of Using Kolibri by Selected Government Schools in Uganda. *Journal of Learning for Development*, 7(3), 447–458. <https://doi.org/10.56059/jl4d.v7i3.465> ([details](#))
239. Groeneveld, C., Kimenyi, E., & Kaye, T. (2021). SWOT Analysis of the Kenya Education Cloud. EdTech Hub. ([details](#))
240. Chandra, S. (2020). Why the World Needs a Curriculum Alignment Hub. Learning Equality. ([details](#))
241. Lambert, S. (2019). The Siyavula Case: Digital, Collaborative Text-Book Authoring to Address Educational Disadvantage and Resource Shortage in South African Schools. *International Electronic Journal of Elementary Education*, 11(3), 279–290. <https://doi.org/10.26822/iejee.2019349252> ([details](#))
242. Haßler, B., Hennessy, S., & Hofmann, R. (2018). Sustaining and Scaling Pedagogy Innovation in Sub-Saharan Africa: Grounded Insights For Teacher Professional Development. *Journal of Learning for Development*, 5(1). <https://doi.org/10.56059/jl4d.v5i1.264> ([details](#))
243. Hennessy, S., D'Angelo, S., Koomar, S., Adam, T., Cao, L., & Haßler, B. (2023). Technology use in teacher preparation and professional development in low- and middle-income countries. *Global Education Monitoring Report*. ([details](#))
244. Adam, T., El-Sefary, Y., Haßler, B., Khalayleh, A., Kremeia, A., Proctor, J., & Mtebe, J. (2021). The Use of Technology in the CPD Implementation Plan in Tanzania. EdTech Hub. ([details](#))
245. Cilliers, J., Fleisch, B., Kotze, J., Mohohlwanex, N., Taylor, S., & Thulare, T. (2020). Can Virtual Replace In-person Coaching? Experimental Evidence on Teacher Professional Development and Student Learning in South Africa. <https://riseprogramme.org/sites/default/files/inline-files/Virtual%20vs%20InPerson%20Coaching%20Working%20Paper.pdf> ([details](#))
246. Bagby, E., Swift-Morgan, J., Niang, A., & Upadhyay, A. (2022). Achieving Cost-Effective Instructional Coaching at Scale: Evidence from Senegal. Chemonics International. ([details](#))
247. Artuc, E., Cull, R., Dasgupta, S., Fattal, R., Filmer, D., Gine, X., Jacoby, H., Jolliffe, D., Kee, H. L., Klapper, L., Kraay, A., Loayza, N., McKenzie, D., Ozler, B., Rao, V., Rijkers, B., Schmukler, S. L., Toman, M., Wagstaff, A., & Woolcock, M. (2020). Toward Successful Development Policies: Insights from Research in Development Economics [Working Paper]. World Bank. <https://doi.org/10.1596/1813-9450-9133>. ([details](#)) Available under <http://creativecommons.org/licenses/by/3.0/igo>.
- Crawford, L., Hares, S., & Sandefur, J. (2022). What has Worked at Scale? In *Schooling for All Feasible Strategies to Achieve Universal Education*. Centre for Global Development. <https://www.cgdev.org/sites/default/files/schooling-for-all-feasible-strategies-universal-education.pdf> ([details](#)). Schaffner, J., Glewwe, P., & Sharma, U. (Eds.). (2021). *Why Programs Fail: Lessons for Improving Public Service Quality from a Mixed-Methods Evaluation of an Unsuccessful Teacher Training Program in Nepal*. <https://doi.org/10.22004/ag.econ.316663> ([details](#))
248. Simpson, L., Carter, A., Rahman, A., & Plaut, D. (2021). Eight Reasons Why EdTech Doesn't Scale: How sandboxes are designed to counter the issue. EdTech Hub. ([details](#))
249. Stern, J., Jukes, M., Piper, B., DeStefano, J., Mejia, J., Dubeck, P., Carrol, B., Punjabi, M., Harris-Van Keuren, C., & Tufail, F. (2021). Learning at scale: interim report | Unesco IIEP Learning Portal. RTI. <https://learningportal.iiep.unesco.org/en/library/learning-at-scale-interim-report> ([details](#))



250. Banerjee, A., Banerji, R., Berry, J., Duflo, E., Kannan, H., Mukerji, S., Shotland, M., & Walton, M. (2017). From Proof of Concept to Scalable Policies: Challenges and Solutions, with an Application. *Journal of Economic Perspectives*, 31(4), 73–102. <https://doi.org/10.1257/jep.31.4.73> (details).  
Crouch, L., & DeStefano, J. (2017). Doing Reform Differently: Combining Rigor and Practicality in Implementation and Evaluation of System Reforms. <https://www.rti.org/publication/doing-reform-differently> (details).  
Gove, A., Korda Poole, M., & Piper, B. (2017). Designing for Scale: Reflections on Rolling Out Reading Improvement in Kenya and Liberia. *New Directions for Child and Adolescent Development*, 2017(155), 77–95. <https://doi.org/10.1002/cad.20195> (details).  
Nicolai, S., Jordan, K., Adam, T., Myers, C., Jefferies, K., & Lockhart, A. S. (in review). Toward a holistic approach to EdTech effectiveness: Lessons from Covid-19 research in Bangladesh, Ghana, Kenya, Pakistan and Sierra Leone. *International Journal of Educational Development*. (details).  
Schaffner, J., Glewwe, P., & Sharma, U. (Eds.). (2021). Why Programs Fail: Lessons for Improving Public Service Quality from a Mixed-Methods Evaluation of an Unsuccessful Teacher Training Program in Nepal. <https://doi.org/10.22004/ag.econ.316663> (details).
251. Stern, J., Jukes, M., Piper, B., DeStefano, J., Mejia, J., Dubeck, P., Carrol, B., Punjabi, M., Harris-Van Keuren, C., & Tufail, F. (2021). Learning at scale: interim report | Unesco IIEP Learning Portal. RTI. <https://learningportal.iiep.unesco.org/en/library/learning-at-scale-interim-report> (details).  
Yarrow, N., Abbey, C., Shen, S., & Alyono, K. (2023). Using Education Technology to Improve K-12 Student Learning in East Asia Pacific: Promises and Limitations. <https://elibrary.worldbank.org/doi/abs/10.1596/40508>
252. Stern, J., Jukes, M., Piper, B., DeStefano, J., Mejia, J., Dubeck, P., Carrol, B., Punjabi, M., Harris-Van Keuren, C., & Tufail, F. (2021). Learning at scale: interim report | Unesco IIEP Learning Portal. RTI. <https://learningportal.iiep.unesco.org/en/library/learning-at-scale-interim-report> (details)
253. Fabregas, R. (2019). Broadcasting education: The long-term effects of Mexico's telesecundarias. Working Paper. (details). Borghesan, E., & Vasey, G. (2021). The marginal returns to distance education: Evidence from mexico's telesecundarias. (details).
254. Shah, D. (2021, December 14). A Decade of MOOCs: A Review of MOOC Stats and Trends in 2021. The Report by Class Central. <https://www.classcentral.com/report/moocs-stats-and-trends-2021/> (details)
255. Reich, J., & Ruipérez-Valiente, J. A. (2019). The MOOC pivot. *Science*, 363(6423), 130–131. <https://doi.org/10.1126/science.aav7958> (details)
256. Murray, S. (2019, March 4). Moocs struggle to lift rock-bottom completion rates. *Financial Times*. <https://www.ft.com/content/60e90be2-1a77-11e9-b191-175523b59d1d> (details)
257. Emanuel, E. J. (2013). MOOCs taken by educated few. *Nature*, 503(7476), 342–342. <https://doi.org/10.1038/503342a>. (details) Available under 2013 Nature Publishing Group, a division of Macmillan Publishers Limited. All Rights Reserved., Czerniewicz, L., Deacon, A., Small, J., & Walji, S. (2014). Developing world MOOCs: A curriculum view of the MOOC landscape. *Journal of Global Literacies, Technologies, and Emerging Pedagogies*, 2(3), 122–136. (details), Lockley, P. (2018). Open Initiatives for Decolonising the Curriculum. In *Decolonising the University* (pp. 145–173). Pluto Press. (details)
258. France, P. E. (2017). Is Standardization the Answer to Personalization? *Educational Leadership*, 74(6), 40–44. (details), Fisher, J. F. (2018, May 17). Is standardization the enemy of personalization? Not necessarily. Christensen Institute. <https://www.christenseninstitute.org/blog/is-standardization-the-enemy-of-personalization-not-necessarily/> (details)
259. Banerjee, A., Banerji, R., Berry, J., Duflo, E., Kannan, H., Mukherji, S., Shotland, M., & Walton, M. (2016). From Proof of Concept to Scalable Policies: Challenges and Solutions, with an Application (Working Paper 22931). National Bureau of Economic Research. <https://doi.org/10.3386/w22931> (details)
260. Banerjee, A., Banerji, R., Berry, J., Duflo, E., Kannan, H., Mukherji, S., Shotland, M., & Walton, M. (2016). From Proof of Concept to Scalable Policies: Challenges and Solutions, with an Application (Working Paper 22931). National Bureau of Economic Research. <https://doi.org/10.3386/w22931> (details)
261. Muralidharan, K., Singh, A., & Ganimian, A. J. (2019). Disrupting Education? Experimental Evidence on Technology-Aided Instruction in India. *American Economic Review*, 109(4), 1426–1460. <https://doi.org/10.1257/aer.20171112> (details)
262. Perera, M., & Aboal, D. (2019). The impact of a mathematics computer-assisted learning platform on students' mathematics test scores. MERIT Working Papers. <https://ideas.repec.org/p/unm/unumer/2019007.html> (details)
263. Perera, M., & Aboal, D. (2019). The impact of a mathematics computer-assisted learning platform on students' mathematics test scores. MERIT Working Papers. <https://ideas.repec.org/p/unm/unumer/2019007.html> (details)

264. Imagine WorldWide, H. A. (2022). Building Educational Foundations through Innovation & Technology (BEFIT) Malawi Scale-Up Program Overview. <https://www.imagine-worldwide.org/wp-content/uploads/Malawi-Project-Overview-General-11-16-22.pdf> (details)
265. Pitchford, N. (2023). Customised E-Learning Platforms. In T. Madon, A. J. Gadgil, R. Anderson, L. Casaburi, K. Lee, & A. Rezaee (Eds.), *Introduction to Development Engineering: A Framework with Applications from the Field* (pp. 269–292). Springer International Publishing. [https://doi.org/10.1007/978-3-030-86065-3\\_11](https://doi.org/10.1007/978-3-030-86065-3_11) (details)
266. Groeneveld, C., Michels, G., & Kaye, T. (2022). Developing a Proof of Concept for a Regional Learning Hub for Eastern and Southern Africa Part 5: Final report. EdTech Hub. (details)
267. Learning Passport. (n.d.). Learning Passport: Where We Work. UNICEF. Retrieved December 26, 2022, from <https://www.learningpassport.org/where-we-work> (details)
268. Learning Passport. (n.d.). Learning Passport: Where We Work. UNICEF. Retrieved December 26, 2022, from <https://www.learningpassport.org/where-we-work> (details)
269. UNCEF ECARO. (2021). LearnIn Implementation Plan 2020 - 2025. <https://www.unicef.org/eca/media/19846/file> (details)
270. UNICEF Kosovo Office. (2021). Reimagine Education with the Learning Passport: The case of Kosovo. UNICEF. <https://www.unicef.org/kosovoprogramme/media/2511/file/Case%20Study%20Learning%20Passport.pdf> (details)
271. UNICEF Kosovo Office. (2021). Reimagine Education with the Learning Passport: The case of Kosovo. UNICEF. <https://www.unicef.org/kosovoprogramme/media/2511/file/Case%20Study%20Learning%20Passport.pdf> (details)
272. Pritchett, L. (2015). Creating Education Systems Coherent for Learning Outcomes: Making the Transition from Schooling to Learning (Research on Improving Systems of Education, p. 47). Rise Programme. (details)
273. Gustafsson-Wright, E., Osborne, S., & Aggarwal, M. (2022, November 2). Digital tools for real-time data collection in education. Brookings. <https://policycommons.net/artifacts/4142237/digital-tools-for-real-time-data-collection-in-education/4951284/> (details)
274. Pritchett, L. (2018). The Risks of Dangerous Dashboards in Basic Education. Research on Improving Systems of Education (RISE). [https://doi.org/10.35489/BSG-RISE-RI\\_2018/006](https://doi.org/10.35489/BSG-RISE-RI_2018/006) (details)
275. Platform, I. L. (2023). EdTech Evidence Mid-Year Report. <https://www.instructure.com/resources/research-reports/edtech-evidence-2023-mid-year-report>
276. McBurnie, C., & Beoku-Betts, I. (2021). Mapping the education data ecosystem in Sierra Leone. EdTech Hub. (details)  
  
Selwaness, I., Adam, T., Lawson, L., & Heady, L. (2022). Guidance Note on Education Data Mapping in Sub-Saharan Africa: Moving from theory to practice. EdTech Hub. (details)  
  
UNESCO. (2021). Strengthening education management information systems for increased resilience to crises: a synthesis of case studies - UNESCO Digital Library. <https://unesdoc.unesco.org/ark:/48223/pf0000378150> (details).
277. UNESCO. (2021). Strengthening education management information systems for increased resilience to crises: a synthesis of case studies - UNESCO Digital Library. <https://unesdoc.unesco.org/ark:/48223/pf0000378150> (details)
278. Mwaniki, D. (2021). Strengthening Education Management Information Systems (EMIS) and Data for Increased Resilience to Crisis: country case study: South Sudan. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000375815?posInSet=3&queryId=e42c738a-ce84-4fa7-ba4a-dea123e05842> (details)
279. Szucs, E. (2021). Strengthening Education Management Information Systems (EMIS) and Data for Increased Resilience to Crisis: country case study: Ethiopia - UNESCO Digital Library. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000375813?posInSet=7&queryId=5e6b0872-9326-4b6a-8e57-2634e50b6fe1> (details)
280. Szucs, E. (2021). Strengthening Education Management Information Systems (EMIS) and Data for Increased Resilience to Crisis: country case study: Ethiopia - UNESCO Digital Library. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000375813?posInSet=7&queryId=5e6b0872-9326-4b6a-8e57-2634e50b6fe1> (details)
281. Szucs, E. (2021). Strengthening Education Management Information Systems (EMIS) and Data for Increased Resilience to Crisis: country case study: Ethiopia - UNESCO Digital Library. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000375813?posInSet=7&queryId=5e6b0872-9326-4b6a-8e57-2634e50b6fe1> (details)
282. Alexander, B., Ashford-Rowe, K., Barajas-Murphy, N., Dobbin, G., Knott, J., McCormack, M., Pomerantz, J., Seilhamer, R., & Weber, N. (2019). EDUCAUSE Horizon Report: 2019 Higher Education Edition. EDUCAUSE. (details)

283. Larrabee Sønderlund, A., Hughes, E., & Smith, J. (2019). The efficacy of learning analytics interventions in higher education: A systematic review. *British Journal of Educational Technology*, 50(5), 2594–2618. <https://doi.org/10.1111/bjet.12720> (details), Namoun, A., & Alshaqiti, A. (2021). Predicting Student Performance Using Data Mining and Learning Analytics Techniques: A Systematic Literature Review. *Applied Sciences*, 11(1), 237. <https://doi.org/10.3390/app11010237>. (details) Available under <http://creativecommons.org/licenses/by/3.0/>.
284. Ruiz-Calleja, A., Garcia, S., Tammets, K., Aguerrebere, C., & Ley, T. (2019). Scaling Learning Analytics up to the national level: the experience from Estonia and Uruguay. (details)
285. Olubendi, D. (2019). A Framework For Evaluating The Outcome Of Use Of ICTOn Early Grade Literacy Assessment; A Case Study Of Tusome Literacy Programme In Kenya [Thesis, University of Nairobi]. <http://erepository.uonbi.ac.ke/handle/11295/109880>. (details) Available under Attribution-NonCommercial-NoDerivs 3.0 United States.
286. Olubendi, D. (2019). A Framework For Evaluating The Outcome Of Use Of ICTOn Early Grade Literacy Assessment; A Case Study Of Tusome Literacy Programme In Kenya [Thesis, University of Nairobi]. <http://erepository.uonbi.ac.ke/handle/11295/109880>. (details) Available under Attribution-NonCommercial-NoDerivs 3.0 United States.
287. Friedberg, A. (2022). Introducing EIDU's Solver Platform: Facilitating Open Collaboration in AI to Help Solve the Global Learning Crisis. In M. M. Rodrigo, N. Matsuda, A. I. Cristea, & V. Dimitrova (Eds.), *Artificial Intelligence in Education. Posters and Late Breaking Results, Workshops and Tutorials, Industry and Innovation Tracks, Practitioners' and Doctoral Consortium* (pp. 104–108). Springer International Publishing. [https://doi.org/10.1007/978-3-031-11647-6\\_18](https://doi.org/10.1007/978-3-031-11647-6_18) (details)
288. Dial. (2019). SDG Digital Investment Framework A Whole-of-Government Approach to Investing in Digital Technologies to Achieve the SDGs. [https://www.itu.int/dms\\_pub/itu-d/opb/str/D-STR-DIGITAL.02-2019-PDF-E.pdf](https://www.itu.int/dms_pub/itu-d/opb/str/D-STR-DIGITAL.02-2019-PDF-E.pdf) (details)
289. Adam, T., El-Sefary, Y., Haßler, B., Khalayleh, A., Kremeia, A., Proctor, J., & Mtebe, J. (2021). The Use of Technology in the CPD Implementation Plan in Tanzania. *EdTech Hub*. (details)
290. Choudary, S. P., & Maruwada, S. (2022). The building block thesis. (details)
291. Han, H. J. (2022). “How Dare They Peep into My Private Life?” Human Rights Watch. <https://www.hrw.org/report/2022/05/25/how-dare-they-peep-my-private-life/childrens-rights-violations-governments> (details)
292. West, T. (2022, November 3). Children's Privacy: An Evaluation of EdTech Privacy Policies. (details)
293. Marlow, C. (2023). Digital Dystopia The Danger in Buying What the EdTech Surveillance Industry is Selling. American Civil Liberties Union (ACLU). (details)
294. Hillman, V. (forthcoming). Taming (ed)Tech: Why Children Stand to Lose in an Unregulated Digital Education. Bloomsbury Academic. (details)
295. Han, H. J. (2022). “How Dare They Peep into My Private Life?” Human Rights Watch. <https://www.hrw.org/report/2022/05/25/how-dare-they-peep-my-private-life/childrens-rights-violations-governments> (details)
296. ICO (UK). (2022, October 17). 12. Profiling. <https://ico.org.uk/for-organisations/guide-to-data-protection/ico-codes-of-practice/age-appropriate-design-a-code-of-practice-for-online-services/12-profiling/> (details)
297. OECD. (2020, April 3). Learning remotely when schools close: How well are students and schools prepared? Insights from PISA. OECD. <https://www.oecd.org/coronavirus/policy-responses/learning-remotely-when-schools-close-how-well-are-students-and-schools-prepared-in-sights-from-pisa-3bfda1f7/> (details)
298. Gross, J. (2023). How Finland Is Teaching a Generation to Spot Misinformation. *The New York Times*. <https://doi.org/10.2307/jj.1357298> (details)
299. Doyle, C. (2021). The outcomes of sexting for children and adolescents: A systematic review of the literature. *Journal of Adolescence*, 92(October), 86–113. <https://doi.org/10.1016/j.adolescence.2021.08.009> (details).
300. Heikkilä, H., Maalouf, W., & Campello, G. (2021). The United Nations Office on Drugs and Crime's Efforts to Strengthen a Culture of Prevention in Low- and Middle-Income Countries. *Prevention Science*, 22(1), 18–28. <https://doi.org/10.1007/s11121-020-01088-5> (details)
301. Korte, M. (2020). The impact of the digital revolution on human brain and behavior: where do we stand? *Dialogues in Clinical Neuroscience*, 22(2), 101–111. <https://doi.org/10.31887/DCNS.2020.22.2/mkorte> (details)
302. Barry, E. (2023, January 3). Social Media Use Is Linked to Brain Changes in Teens, Research Finds. *The New York*

- Times. <https://www.nytimes.com/2023/01/03/health/social-media-brain-adolescents.html> (details)
303. Zhu, C., Huang, S., Evans, R., & Zhang, W. (2021). Cyberbullying Among Adolescents and Children: A Comprehensive Review of the Global Situation, Risk Factors, and Preventive Measures. *Frontiers in Public Health*, 9. <https://doi.org/10.3389/fpubh.2021.634909> (details)
304. World Economic Forum. (2022). Global Risks Report 2022. World Economic Forum. <https://www.weforum.org/reports/global-risks-report-2022/in-full/> (details)
305. Sophos. (2022). The State of Ransomware in Education 2022 – Sophos Partner News. Sophos Partner News July, 12. <https://partnernews.sophos.com/en-us/2022/07/resources/the-state-of-ransomware-in-education-2022/> (details)
306. Kuykendall, B. K. (2022). New California Law Requires Schools to Report All Cyberattacks Impacting 500 or More -. *THE Journal*. <https://thejournal.com/articles/2022/10/06/new-california-law-requires-schools-to-report-all-cyber-incidents-impacting-500-pupils-or-staff.aspx>. (details)
307. Hasse, A. (2019). Youth and Artificial Intelligence.“Berkman Klein Center. <https://cyber.harvard.edu/publication/2019/youth-and-artificial-intelligence/where-we-stand> (details)
308. Caines, A., & Silverman, S. (2021, December 10). Back Doors, Trap Doors, and Fourth-Party Deals: How You End up with Harmful Academic Surveillance Technology on Your Campus without Even Knowing. *The Journal of Interactive Technology and Pedagogy*. <https://jitp.commons.gc.cuny.edu/?p> (details)
309. Fernández-Batanero, J.-M., Román-Graván, P., Reyes-Rebollo, M.-M., & Montenegro-Rueda, M. (2021). Impact of Educational Technology on Teacher Stress and Anxiety: A Literature Review. *International Journal of Environmental Research and Public Health*, 18(2), 548. <https://doi.org/10.3390/ijerph18020548>. (details) Available under <http://creativecommons.org/licenses/by/3.0/>.
310. Trucano, M. (2023). AI and the Next Digital Divide in Education. (details)
311. Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European Journal of Education*, 57(4), 542–570. <https://doi.org/10.1111/ejed.12533> (details)
312. Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in Education: Towards a Community-Wide Framework. *International Journal of Artificial Intelligence in Education*, 32(3), 504–526. <https://doi.org/10.1007/s40593-021-00239-1> (details)
313. Hernandez-de-Menendez, M., Morales-Menendez, R., Escobar, C. A., & Arinez, J. (2021). Biometric applications in education. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 15(2), 365–380. <https://doi.org/10.1007/s12008-021-00760-6> (details)
314. Sarwar, M. B. (2022, April 21). Reading Audrey Watters: A reflection on personalised learning via education technology through a decolonial lens. *EdTech Hub*. <https://edtech-hub.org/2022/04/21/personalised-learning/> (details)
315. Mills, M., & Whittaker, M. (2019). Disability, Bias, and AI. *AI Now Institute Report*. (details)
316. OECD. (2021). Development Co-operation Report 2021: Shaping a Just Digital Transformation. Organisation for Economic Co-operation and Development. <https://doi.org/10.1787/ce08832f-en> (details)
- OECD. (2021). Children in the digital environment: Revised typology of risks. OECD. <https://doi.org/10.1787/9b-8f222e-en> (details)
- OECD. (2021). OECD Legal Instruments. <https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0389%20> (details)
317. Adam, T. (2019). Digital neocolonialism and massive open online courses (MOOCs): colonial pasts and neoliberal futures. *Learning, Media and Technology*, 44(3), 365–380. <https://doi.org/10.1080/17439884.2019.1640740> (details)
318. Czerniewicz, L. (2018). Unbundling and Rebundling Higher Education in an Age of Inequality. <https://er.educause.edu/articles/2018/10/unbundling-and-rebundling-higher-education-in-an-age-of-inequality> (details)
319. Williamson, B. (2022). Big EdTech. *Learning, Media and Technology*, 47(2), 157–162. <https://doi.org/10.1080/17439884.2022.2063888> (details)
320. Council of Europe. (2021). Children’s data protection in an education setting - Guidelines. Council of Europe Publishing. <https://edoc.coe.int/en/children-and-the-inter-net/9620-childrens-data-protection-in-an-education-setting-guidelines.html> (details)
321. ITU. (2020). Child Online Protection I ITU COP Guidelines. <https://www.itu-cop-guidelines.com/> (details)
322. GPA. (n.d.). Adopted Resolutions – Global Privacy Assem-



- bly. Retrieved January 6, 2023, from <https://globalprivacyassembly.org/document-archive/adopted-resolutions/details>
323. OECD. (2021). Development Co-operation Report 2021: Shaping a Just Digital Transformation. Organisation for Economic Co-operation and Development. <https://doi.org/10.1787/ce08832f-en> (details)
- OECD. (2021). OECD Legal Instruments. <https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0389%20> (details)
- OECD. (2021). Children in the digital environment: Revised typology of risks. OECD. <https://doi.org/10.1787/9b8f222e-en> (details)
324. Child Rights Impact Assessment - A tool to realise children's rights in the digital environment. (2021). <http://fra.europa.eu/en/content/child-rights-impact-assessment/details>
325. Child rights impact assessment. (2014, November 24). European Union Agency for Fundamental Rights. <https://digital-futurescommission.org.uk/wp-content/uploads/2021/03/CRIA-Report.pdf> (details)
326. Council of Europe. (2021). Children's data protection in an education setting - Guidelines. Council of Europe Publishing. <https://edoc.coe.int/en/children-and-the-internet/9620-childrens-data-protection-in-an-education-setting-guidelines.html> (details)
327. The LEGO Group. (2018). Responsibility Report 2018. (details)
328. Global Education's Tech Reboot. (n.d.). Morgan Stanley. Retrieved March 19, 2024, from <https://www.morganstanley.com/ideas/education-system-technology-reboot/details>
329. Adkins, S. S. (2020). The 2019 Global Learning Technology Investment Patterns: Another Record Shattering Year. <https://users.neo.registeredsite.com/9/8/1/17460189/assets/Metaari-2019-Global-Learning-Technology-Investment-Patterns.pdf> (details)
- Labun, J. (2023). Fixing Ed-Tech's Investment Model. [https://ssir.org/articles/entry/fixing\\_ed\\_techs\\_investment\\_model](https://ssir.org/articles/entry/fixing_ed_techs_investment_model). (details)
330. Allman, B., Kimmons, R., Rosenberg, J., & Dash, M. (2023). Trends and Topics in Educational Technology, 2023 Edition. TechTrends, 67(3), 583–591. <https://doi.org/10.1007/s11528-023-00840-2> (details)
- Bozkurt, A. (2020). Educational Technology Research Patterns in the Realm of the Digital Knowledge Age. Journal of Interactive Media in Education, 2020(1), 1–17. <https://doi.org/10.5334/jime.570> (details)
- Platform, I. L. (2023). EdTech Evidence Mid-Year Report. <https://www.instructure.com/resources/research-reports/edtech-evidence-2023-mid-year-report#:~:text=This%20report%20looks%20at%20the,%2D%20December%2031%2C%202022> (details)
331. Labun, J. (2023). Fixing Ed-Tech's Investment Model. [https://ssir.org/articles/entry/fixing\\_ed\\_techs\\_investment\\_model](https://ssir.org/articles/entry/fixing_ed_techs_investment_model). (details)
332. Wylie, Louise. (2024). Education App Revenue and Usage Statistics. [Business of Apps](#), accessed Jan 28, 2024.
333. Shing, S., & Yuan, B. (2016). Apps Developed by Academics. Journal of Education and Practice, 7(33), 1–9. (details)
- Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in “educational” apps lessons from the science of learning. Psychological Science in the Public Interest, 16(1), 3–34.
334. Darling-Hammond, L., Zielesinski, M., & goldman, shelley. (2014). Using Technology to Support At-Risk Students' Learning. Alliance for Excellent Education. (details)
335. Asian Development Bank. (2023). Reimagine Tech-Inclusive Education: Evidence, Practices, and Road Map. Asian Development Bank. <https://doi.org/10.22617/TCS230233> (details)
336. Asian Development Bank. (2023). Reimagine Tech-Inclusive Education: Evidence, Practices, and Road Map. Asian Development Bank. <https://doi.org/10.22617/TCS230233> (details)
337. Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). The Effectiveness of Online and Blended Learning: A Meta-Analysis of the Empirical Literature. Teachers College Record: The Voice of Scholarship in Education, 115(3), 1–47. <https://doi.org/10.1177/016146811311500307> (details)
338. McNiff, J. (2017). Action Research: All You Need to Know (First edition). SAGE Publications Ltd. (details)
339. American Institute for Research. (2018). Sequential, Multiple Assignment, Randomized Trial. <https://optimizingoutcomes.air.org/innovative-designs.php> (details)
340. Crowley, K. (2016). Design-Based Research and Design-Based Implementation Research | InformalScience.org. <https://>

[www.informalscience.org/news-views/design-based-research-and-design-based-implementation-research](http://www.informalscience.org/news-views/design-based-research-and-design-based-implementation-research) (details)

341. Ubaidullah, A. (2016, June 10). Design Based Implementation Research (DBIR) for Sustaining Innovation in Classroom Instruction. Changing Classrooms - Challenges For Teachers & Teacher Educators. (details)
342. Samji, S., Andrews, M., Pritchett, L., & Woolcock, M. (2018). PDIA toolkit: A DIY Approach to Solving Complex Problems. Center for International Development at Harvard University. [https://bsc.cid.harvard.edu/files/bsc/files/pdia-toolkit\\_ver\\_1\\_oct\\_2018.pdf](https://bsc.cid.harvard.edu/files/bsc/files/pdia-toolkit_ver_1_oct_2018.pdf) (details)
343. EdTech Hub. (2022). Sandbox Handbook V.2.0. EdTech Hub. (details)
344. Boujikian, M., Carter, A., & Jordan, K. (2022). The Sandbox Model: A Novel Approach to Iterating while Implementing an Emergency Education Program in Lebanon during the COVID-19 Pandemic. Journal on Education in Emergencies, 8(3), 215. <https://doi.org/10.33682/rj45-k7z7> (details)
345. Principles of Digital Development. (2022). Design for Scale. Principles for Digital Development. <https://digitalprinciples.org/principle/design-for-scale/> (details)
346. Simpson, L., Carter, A., Rahman, A., & Plaut, D. (2021). Eight Reasons Why EdTech Doesn't Scale: How sandboxes are designed to counter the issue. EdTech Hub. (details)
347. Simpson, L., Carter, A., Rahman, A., & Plaut, D. (2021). Eight Reasons Why EdTech Doesn't Scale: How sandboxes are designed to counter the issue. EdTech Hub. (details)
- Principles of Digital Development. (2022). Design for Scale. Principles for Digital Development. <https://digitalprinciples.org/principle/design-for-scale/> (details)
348. Nahum-Shani, I., Almirall, D., & Buckley, J. (2020). An Introduction to Adaptive Interventions and SMART Designs in Education. (details)
349. Haßler, B., El-Serafy, Y., Khalayleh, A., & McBurnie, C. (2021). Systemic Mixed-Methods Research—a conceptual framework for scalable EdTech research. EdTech Hub. (details)
350. Ewens, W. J., & Grant, G. R. (2001). Computationally Intensive Methods. In W. J. Ewens & G. R. Grant (Eds.), Statistical Methods in Bioinformatics: An Introduction (pp. 349–363). Springer. [https://doi.org/10.1007/978-1-4757-3247-4\\_12](https://doi.org/10.1007/978-1-4757-3247-4_12) (details)
351. Ewens, W. J., & Grant, G. R. (2001). Computationally Intensive Methods. In W. J. Ewens & G. R. Grant (Eds.), Statistical Methods in Bioinformatics: An Introduction (pp. 349–363). Springer. [https://doi.org/10.1007/978-1-4757-3247-4\\_12](https://doi.org/10.1007/978-1-4757-3247-4_12) (details)
352. EEF. (2021). National Tutoring Programme: Nimble RCTs. EEF. <https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/national-tutoring-programme-nimble-rcts> (details)
353. Zhan, R., Zhimei, R., Athey, S., & Zhou, Z. (2021). Policy Learning with Adaptively Collected Data. <https://www.gsb.stanford.edu/faculty-research/working-papers/policy-learning-adaptively-collected-data> (details)
354. Xiong, R., Athey, S., Imben, G. W., & Bayati, M. (2019). Optimal Experimental Design for Staggered Rollouts. Stanford Graduate School of Business. <https://www.gsb.stanford.edu/faculty-research/working-papers/optimal-experimental-design-staggered-rollouts> (details)
355. Haßler, B., El-Serafy, Y., Khalayleh, A., & McBurnie, C. (2021). Systemic Mixed-Methods Research—a conceptual framework for scalable EdTech research. EdTech Hub. (details)
356. Yeung, K. L., Carpenter, S. K., & Corral, D. (2021). A Comprehensive Review of Educational Technology on Objective Learning Outcomes in Academic Contexts. Educational Psychology Review, 33(4), 1583–1630. <https://doi.org/10.1007/s10648-020-09592-4> (details)
357. Kerwin, J. T., & Thornton, R. L. (2020). Making the Grade: The Sensitivity of Education Program Effectiveness to Input Choices and Outcome Measures. The Review of Economics and Statistics, 1–45. [https://doi.org/10.1162/rest\\_a\\_00911](https://doi.org/10.1162/rest_a_00911) (details)
358. Plaut, D., Carter, A., Dixon, M., & Salami, T. (2020). EdTech Innovation for COVID-19: Insights from our global call for ideas. <https://doi.org/10.5281/zenodo.4768571> (details)
359. Adam, T., Chuang, R., & Haßler, B. (2021). Structured Pedagogy and EdTech. EdTech Hub. (details)
360. Wilson-Grau, R. (2018). Outcome Harvesting: Principles, Steps, and Evaluation Applications. (details)
361. Wasserman, S., & Faust, K. (1994). Social Network Analysis. <https://doi.org/10.1017/CBO9780511815478> (details)
362. Pasanen, T., & Barnett, I. (2019). Supporting adaptive management. (details)

363. Whaites, A. (2017). The\_Beginner\_s\_Guide\_to\_PEA.pdf. UKAID. [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/766478/The\\_Beginner\\_s\\_Guide\\_to\\_PEA.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766478/The_Beginner_s_Guide_to_PEA.pdf) (details)
364. Forman, S. G., Shapiro, E. S., Coddington, R. S., Gonzales, J. E., Reddy, L. A., Rosenfield, S. A., Sanetti, L. M., & Stoiber, K. C. (2013). Implementation science and school psychology. *School Psychology Quarterly*, 28(2), 77. <https://doi.org/10.1037/spq0000019> (details)
365. Kerwin, J. T., & Thornton, R. L. (2020). Making the Grade: The Sensitivity of Education Program Effectiveness to Input Choices and Outcome Measures. *The Review of Economics and Statistics*, 1–45. [https://doi.org/10.1162/rest\\_a\\_00911](https://doi.org/10.1162/rest_a_00911) (details)
366. Rajasekaran, S., & Casap, L. (2022). MOLDOVA – DIGITAL EDUCATION READINESS ASSESSMENT 2021-22. World Bank Group. <http://documents.worldbank.org/curated/en/09912000625220689/P17773104ea-6f2040a88e02bdf9bbd04f6>. (details)
- Adam, T., McBurnie, C., & Haßler, B. (2020). Rolling Out a National Virtual Learning Environment. *EdTech Hub*. (details)
- Ganimian, A. J., Vegas, E., & Hess, F. M. (2020, September 10). Realizing the promise: How can education technology improve learning for all? *Brookings*. <https://www.brookings.edu/essay/realizing-the-promise-how-can-education-technology-improve-learning-for-all/> (details)
367. Cullinan, J., Flannery, D., Harold, J., Lyons, S., & Palcic, D. (2021). The disconnected: COVID-19 and disparities in access to quality broadband for higher education students. *International Journal of Educational Technology in Higher Education*, 18(1), 26. <https://doi.org/10.1186/s41239-021-00262-1> (details)
368. Cullinan, J., Flannery, D., Harold, J., Lyons, S., & Palcic, D. (2021). The disconnected: COVID-19 and disparities in access to quality broadband for higher education students. *International Journal of Educational Technology in Higher Education*, 18(1), 26. <https://doi.org/10.1186/s41239-021-00262-1> (details)
369. Godaert, E., Aesaert, K., Voogt, J., & Van Braak, J. (2022). Assessment of students' digital competences in primary school: a systematic review. *Education and Information Technologies*, 27(7), 9953–10011. <https://doi.org/10.1007/s10639-022-11020-9> (details).
- Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Mathematics, Science and Technology Education*, 5(3), 235–245. <https://doi.org/10.12973/ejmste/75275> (details)
- Freeman, A., Becker, S. A., & Cummins, M. (2017). NMC/CoSN horizon report: 2017 K. The New Media Consortium. <https://www.learntechlib.org/p/182003/> (details)
- Omidyar Network. (2019). Scaling Access & Impact Realizing the Power of EdTech. [https://assets.imaginablefutures.com/media/documents/ON\\_Scaling\\_Access\\_Impact\\_2019\\_85x11\\_Online.pdf](https://assets.imaginablefutures.com/media/documents/ON_Scaling_Access_Impact_2019_85x11_Online.pdf) (details)
370. Resta, P., & Laferrière, T. (2015). Digital equity and intercultural education. *Education and Information Technologies*, 20(4), 743–756. <https://doi.org/10.1007/s10639-015-9419-z> (details)
371. Unwin, T., Naseem, A., Pawluczuk, A., Shareef, M., Spiesberger, P., West, P., & Yoo, C. (2020). Education for the most marginalised post-COVID-19: Guidance for governments on the use of digital technologies in education ACT TWO (OF THREE): FULL REPORT (p. 118). *EdTech Hub, UNESCO, UniTwin*. (details)
- Unwin, T., Naseem, A., Pawluczuk, A., Shareef, M., Spiesberger, P., West, P., & Yoo, C. (2020). Education for the most marginalised post-COVID-19: Guidance for governments on the use of digital technologies in education – Act one. *UNESCO, UniTwin, EdTech Hub*. (details)
- International Forum on AI and the Futures of Education, developing competencies for the AI Era, 7-UNESCO. (2020). December 2020: synthesis report - UNESCO Digital Library. (n.d.). Retrieved December 27, 2022, from <https://unesdoc.unesco.org/ark:/48223/pf0000377251> (details)
372. Krumsvik, R. J. (2014). Teacher educators' digital competence. *Scandinavian Journal of Educational Research*, 58(3), 269–280. <https://doi.org/10.1080/00313831.2012.726273> (details)
373. OECD. (2015). Does having digital skills really pay off? OECD. <https://doi.org/10.1787/5js023r0wj9v-en> (details)
374. OECD (2019), Measuring the Digital Transformation: A Roadmap for the Future, OECD Publishing, Paris, <https://doi.org/10.1787/9789264311992-en>
375. UNICEF, I. T. U. (2020). Two Thirds of the World's School-Age Children Have No Internet Access at Home, New UNICEF-ITU Report Says. <https://www.unicef.org/press-releases/two-thirds-worlds-school-age-children-have-no-internet-access-home-new-unicef-itu> (details)

376. Freitas, E., Fonseca, F., Garcia, V., Ferreira, R., & Gašević, D. (2020). Towards a Maturity Model for Learning Analytics Adoption An Overview of its Levels and Areas. 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT), 122–126. <https://doi.org/10.1109/ICALT49669.2020.00059> (details)
377. General Data Protection Regulation (GDPR) – Official Legal Text. Retrieved March 19, 2024, from <https://gdpr-info.eu/> (details)
378. Lenovo. (2023, March 21). Lenovo Focuses on Digital Inclusion with Launch of Bilingual Keyboard. Lenovo StoryHub. <https://news.lenovo.com/pressroom/press-releases/digital-inclusion-maori-bilingual-keyboard/> (details)
379. Lenovo. (2023, March 21). Lenovo Focuses on Digital Inclusion with Launch of Bilingual Keyboard. Lenovo StoryHub. <https://news.lenovo.com/pressroom/press-releases/digital-inclusion-maori-bilingual-keyboard/> (details)
380. Salmi, J. (2020). COVID's Lessons for Global Higher Education: Coping with the Present While Building a More Equitable Future. Lumina Foundation. <https://eric.ed.gov/?id=ED611329> (details)
381. Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Gebhardt, E. (2014). Students' Use of and Engagement with ICT at Home and School. In J. Fraillon, J. Ainley, W. Schulz, T. Friedman, & E. Gebhardt, Preparing for Life in a Digital Age (pp. 125–166). Springer International Publishing. [https://doi.org/10.1007/978-3-319-14222-7\\_6](https://doi.org/10.1007/978-3-319-14222-7_6) (details)
- Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Gebhardt, E. (2014). Preparing for life in a digital age: The IEA International Computer and Information Literacy Study international report. Springer Nature. <https://library.oapen.org/bitstream/handle/20.500.12657/28001/1001996.pdf> (details)
382. Tondeur, J., Van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: a systematic review of qualitative evidence. Educational Technology Research and Development, 65(3), 555–575. <https://doi.org/10.1007/s11423-016-9481-2> (details)
383. OECD (2023), OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem, Chapter 7, OECD Publishing, Paris, <https://doi.org/10.1787/c74f03de-en>.
- Jeon, S., Son, Y., & Park, S. (2020). Analysis of the ICILS 2018 Results by Korean Students' Educational Experience in Computer and Information Literacy and Computational Thinking. The Journal of Korean Association of Computer Education, 23(3), 1–8. <https://koreascience.kr/article/JAKO202023852335493.page> (details)
384. Ritzhaupt, A. D., & Hohlfeld, T. N. (2018). An examination of the digital divide and its dividing factors in formal educational settings. Crossing the Bridge of the Digital Divide: A Walk with Global Leaders, 19–36. (details)
385. Minea-Pic, A. (2020), "Innovating teachers' professional learning through digital technologies", OECD Education Working Papers, No. 237, OECD Publishing, Paris, <https://doi.org/10.1787/3329fae9-en>.
386. Boeskens, L. and D. Nusche (2021), "Not enough hours in the day: Policies that shape teachers' use of time", OECD Education Working Papers, No. 245, OECD Publishing, Paris, <https://doi.org/10.1787/15990b42-en>.
387. Russell, R., Kim, L., Hamilton, L., Lazovich, T., Harer, J., Ozdemir, O., Ellingwood, P., & McConley, M. (2018). Automated vulnerability detection in source code using deep representation learning. 2018 17th IEEE International Conference on Machine Learning and Applications (ICMLA), 757–762. <https://doi.org/10.1109/ICMLA.2018.00120> (details)
388. Bhanot, N., Ahuja, J., Kidwai, H. I., Nayan, A., & Bhatti, R. S. (2023). A sustainable economic revival plan for post-COVID-19 using machine learning approach—a case study in developing economy context. Benchmarking: An International Journal, 30(6), 1782–1805. <https://doi.org/10.1108/BIJ-09-2021-0564> (details)
389. VERGER, A., & MOSCHETTI, M. (2017). Partnering with the private sector in the post-2015 era? The main political and social implications in the educational arena. Progressive Lab for Sustainable Development, 245. [https://www.academia.edu/download/53505790/Verger\\_Moschetti\\_2017.pdf](https://www.academia.edu/download/53505790/Verger_Moschetti_2017.pdf) (details)
390. Barrera-Osorio, F., & Linden, L. L. (2009). The Use And Misuse Of Computers In Education: Evidence From A Randomized Experiment In Colombia. The World Bank. <https://doi.org/10.1596/1813-9450-4836> (details)
- C., R., F., S., & J, M. Z. (2011). Impacto del Programa "Computadores para Educar" en la deserción estudiantil, el logro escolar y el ingreso a la educación superior [Impact of the Programme Computers to Educate on Student Dropout, School Achievement and Admission to Higher Education. Serie Documentos CEDe, 15. <https://repositorio.uniandes.edu.co/bitstream/handle/1992/8254/dcede2011-15.pdf?sequence=1&isAllowed=y> (details)



391. Loonam, J., & O'Regan, N. (2022). Global value chains and digital platforms: Implications for strategy. *Strategic Change*, 31(1), 161-177.
392. Omidyar Network. (2019). Scaling Access & Impact Realizing the Power of EdTech. [https://assets.imaginablefutures.com/media/documents/ON\\_Scaling\\_Access\\_Impact\\_2019\\_85x11\\_Online.pdf](https://assets.imaginablefutures.com/media/documents/ON_Scaling_Access_Impact_2019_85x11_Online.pdf) (details)
393. Rajasekaran, S., & Casap, L. (2022). MOLDOVA – DIGITAL EDUCATION READINESS ASSESSMENT 2021-22. World Bank Group. <http://documents.worldbank.org/curated/en/099120006252220689/P17773104ea-6f2040a88e02bdf9bbd04f6>. (details)
394. Czerniewicz, L. (2018). Unbundling and Rebundling Higher Education in an Age of Inequality. <https://er.educause.edu/articles/2018/10/unbundling-and-rebundling-higher-education-in-an-age-of-inequality> (details)
395. Denford, J. (2016). Idea to Retire: Decentralized IT Governance. (details)
396. Arrieta-Ibarra, I., Goff, L., Jiménez-Hernández, D., Lanier, J., & Weyl, E. G. (2018). Should We Treat Data as Labor? Moving beyond “Free.” *AEA Papers and Proceedings*, 108, 38–42. <https://doi.org/10.1257/pandp.20181003> (details)
- Posner, E. A., & Weyl, E. G. (2018). *Radical Markets: Uprooting Capitalism and Democracy for a Just Society*. In *Radical Markets*. Princeton University Press. <https://doi.org/10.23943/9781400889457>. (details) Available under De Gruyter expressly reserves the right to use all content for commercial text and data mining within the meaning of Section 44b of the German Copyright Act..
- Zhu, F. (2019). Friends or foes? Examining platform owners' entry into complementors' spaces. *Journal of Economics & Management Strategy*, 28(1), 23–28. <https://doi.org/10.1111/jems.12303>. (details)
397. Stackpole, T. (2022). What Is Web3? *Harvard Business Review*. <https://hbr.org/2022/05/what-is-web3>. (details)
398. Kud, A. (2023). Decentralized Information Platforms in Public Governance: Reconstruction of the Modern Democracy or Comfort Blinding? *International Journal of Public Administration*, 46(3), 195–221. <https://doi.org/10.1080/01900692.2021.1993905> (details)
- Yan Chen, Jack I. Richter, & Pankaj C. Patel. (2020, April 30). Decentralized Governance of Digital Platforms - Yan Chen, Jack I. Richter, Pankaj C. Patel, 2021. <https://journals.sagepub.com/doi/10.1177/0149206320916755> (details)
399. Commission, D. F. (2023). A Blueprint for Education Data: Realising Children's Best Interests in Digitised Education. <https://digitalfuturescommission.org.uk/wp-content/uploads/2023/03/A-Blueprint-for-Education-Data-FINAL-Online.pdf> (details)
400. Chui, M., & Sarakatsannis, J. (2015). Protecting Student Data in a Digital World. <https://www.mckinsey.com/industries/education/our-insights/protecting-student-data-in-a-digital-world>. (details)
401. OECD Directorate for Education and Skills. (2023). [https://one.oecd.org/document/EDU/EDPC/SR\(2023\)2/en/pdf](https://one.oecd.org/document/EDU/EDPC/SR(2023)2/en/pdf) (details)
402. OECD Directorate for Education and Skills. (2023). [https://one.oecd.org/document/EDU/EDPC/SR\(2023\)2/en/pdf](https://one.oecd.org/document/EDU/EDPC/SR(2023)2/en/pdf) (details)
403. OECD Directorate for Education and Skills. (2023). [https://one.oecd.org/document/EDU/EDPC/SR\(2023\)2/en/pdf](https://one.oecd.org/document/EDU/EDPC/SR(2023)2/en/pdf) (details)
- Olsen, B. (2023). Government Decision-Making on Education in Low- and Middle-Income Countries: Understanding the Fit among Innovation, Scaling Strategy, and Broader Environment. <https://www.brookings.edu/wp-content/uploads/2023/08/Olsen-2023.pdf> (details)
404. Olsen, B. (2023). Government Decision-Making on Education in Low- and Middle-Income Countries: Understanding the Fit among Innovation, Scaling Strategy, and Broader Environment. <https://www.brookings.edu/wp-content/uploads/2023/08/Olsen-2023.pdf> (details)
405. Haßler, B., & Khalayleh, A. (2019). Process for iterative and adaptive implementation of government policy in order to utilise educational technology. (details)
406. Adam, T., El-Sefary, Y., Haßler, B., Khalayleh, A., Kremeia, A., Proctor, J., & Mtebe, J. (2021). The Use of Technology in the CPD Implementation Plan in Tanzania. *EdTech Hub*. (details)
407. Coflan, C., Wyss, N., Thinley, S., & Roland, M. (2022). Developing a national EdTech strategy. *EdTech Hub*. (details)
408. Khalayleh, A. (2021). Determining the suitability of Whatsapp for Jusoor Azima Project [Presentation]. *EdTech Hub*. <https://doi.org/10.5281/zenodo.4783101>. Available under Creative Commons Attribution 4.0 International. (details)
409. gov.uk. (2016). Core principles of agile. *GOV.UK*. <https://www.gov.uk/service-manual/agile-delivery/core-principles-agile> (details)

410. OECD Directorate for Education and Skills. (2023). [https://one.oecd.org/document/EDU/EDPC/SR\(2023\)2/en/pdf\(details\)](https://one.oecd.org/document/EDU/EDPC/SR(2023)2/en/pdf(details))
411. Wilson, K., Gertz, B., Arenth, B., & Salisbury, N. (2014). The Journey to Scale: Moving Together Past Digital Health Pilots (p. 48). PATH. [\(details\)](#)
412. Principles of Digital Development. (2022). Design for Scale. Principles for Digital Development. <https://digitalprinciples.org/principle/design-for-scale/> [\(details\)](#)
413. World Bank. (2018). World development report 2018: Learning to realize education's promise. The World Bank.
414. Tungatarova, A., & van Cappelle, F. (2022). Pulse Check on Digital Learning. UNICEF. [\(details\)](#)
415. Haßler, B., & Khalayleh, A. (2019). Process for iterative and adaptive implementation of government policy in order to utilise educational technology. [\(details\)](#)
416. Bapna, A., Nicolai, S., Myers, C., Pellini, A., Sharma, N., & Wilson, S. (2021). A Case for a Systems Approach to EdTech. EdTech Hub. [\(details\)](#)
417. Al-Hindawi, H., & Hashem, L. (2020). Jordan's EdTech response to COVID-19 [Case Study]. EdTech Hub. <https://doi.org/10.5281/zenodo.4706057> [\(details\)](#)
- Bapna, A., Nicolai, S., Myers, C., Pellini, A., Sharma, N., & Wilson, S. (2021). A Case for a Systems Approach to EdTech. EdTech Hub. [\(details\)](#)
418. Haßler, B., & Khalayleh, A. (2019). Process for iterative and adaptive implementation of government policy in order to utilise educational technology. [\(details\)](#)
419. Hawkins, R., Trucano, M., Cobo, C., Twinomugisha, A., & Ciarrusta, I. S. (n.d.). Technology and Innovation in Education at the World Bank. <https://www.worldbank.org/en/topic/edutech/publication/reimagining-human-connections-technology-and-innovation-in-education-at-world-bank> [\(details\)](#)
- Kickbusch, I., Piselli, D., Agrawal, A., Balicer, R., Banner, O., Adelhardt, M., Capobianco, E., Fabian, C., Gill, A. S., Lupton, D., Medhora, R. P., Ndili, N., Rys, A., Sambuli, N., Settle, D., Swaminathan, S., Morales, J. V., Wolpert, M., Wyckoff, A. W., ... Wong, B. L. H. (2021). The Lancet and Financial Times Commission on governing health futures 2030: growing up in a digital world. The Lancet, 398(10312), 1727–1776. [https://doi.org/10.1016/S0140-6736\(21\)01824-9](https://doi.org/10.1016/S0140-6736(21)01824-9) [\(details\)](#)
420. UNICEF. (2022). Pulse Check on Digital Learning. <https://www.unicef.org/reports/pulse-check> [\(details\)](#)

# Annex 1

## GLOSSARY

**Artificial Intelligence (AI) is the science of teaching machines to learn humanlike capabilities.** Artificial General Intelligence (AGI) is the point at which an AI can perform all human cognitive skills better than the smartest humans. Artificial Capable Intelligence (ACI) can achieve a wide range of complex tasks but is not as far along as AGI.

**Blended Learning** refers to a pedagogic approach that involves a mixed modality of face-to-face teaching and learning as well as distance learning through online, mobile, or other modes for teachers, trainers, and students.

**B2B, B2C, and B2G:** B2B refers to business to business, B2C refers to business to consumer, and B2G refers to business to government. These are three common types of marketing strategies.

**Common data standards, terminologies, and structures on education data** refer to specific provisions about managing information, design, data collection, data verification, and archiving.

**Computational thinking** refers to a set of problem-solving methods that involve expressing problems and their solutions in ways that a computer could also execute. It involves automation of processes and use of computing to explore, analyze, and understand processes (natural and artificial).

**Data specialist** refers to a person with specialized competencies in developing, monitoring, and maintaining databases; monitoring performance; and interpreting raw data and turning it into usable feedback and applications. These are often statistics and computer science experts who can manage the data pipeline and find information signals in the noise of big data.

**Data exchange** refers to the process of sending and receiving data in such a manner that the information content or meaning assigned to the data is not altered during the transmission.

**Data governance** refers to a collection of processes, roles, policies, standards, and metrics that ensure the effective

and efficient use of information in enabling an organization to achieve its goals. It establishes the processes and responsibilities that ensure the quality and security of the data used across a business or organization. Data governance defines who can take what action, upon what data, in what situations, and using what methods.

**Data integrity** refers to the consistency of data on the same variables collected from different sources.

**Data quality** refers to data adequacy, accuracy, relevance, and explanatory capacity to inform decisions.

**EdTech** refers to the private market and innovation ecosystem that develops commercial products, applications, and services for educational and skills development stakeholders. These can include B2C, B2G, B2B products and services.

**Education interventions using digital solutions** refers to education policy, projects, and programmatic interventions that employ digital solutions as part of the intervention design and/or business process redesign. These digital solutions may or may not employ commercial EdTech products and services. It is important to note that this places the education-related outcomes and related interaction processes at the center rather than the technology product/service at the center.

**Interoperability Standards across Applications, Devices, and Equipment** refers to developing and using data standards that enable consistent and accurate collection and exchange of information across systems. This includes mechanisms for information exchange across applications, devices, and equipment that support the country's health, education, and social protection service delivery.

**Digital competencies** refer to the confident and critical use of the full range of digital technologies for information, communication, and basic problem-solving in all aspects of life.

**Digital intensity** refers to the degree to which different industry sectors have adopted digital technologies.

For example, the EU [Digital Intensity Index \(DII\)](#) is a composite indicator derived from the survey on [ICT](#) use and e-commerce in enterprises. Given changes in technology, DII composition variability limits temporal comparability.

**Digital pedagogy** refers to pedagogy supporting the development of digital skills and targeted and methodically meaningful use of digital solutions, learning resources, and content in teaching and learning.

**Digital literacy** refers to the ability to access, manage, understand, integrate, communicate, evaluate, and create information safely and appropriately through digital technologies for employment, decent jobs, and entrepreneurship. It includes competencies that are variously referred to as computer literacy, ICT literacy, information literacy, and media literacy.

**Digital skills** refer to “...skills and competencies needed to make use of digital technology and benefit from its growing power and functionality...” encompassing “...a range of different abilities, many of which are not only ‘skills’ per se, but a combination of behaviors, expertise, know-how, work habits, character traits, dispositions, and critical understandings... best understood as existing on a graduated continuum from basic functional skills to a higher level, specialist skills.”

**(Basic) Digital skills** refer to skills required to operate devices; find and use information; communicate and collaborate; create basic content; understand and apply safety, ethics, and privacy issues; and simple problem-solving and basic computational thinking. Related cognitive domain skills focus on remembering, understanding, and applying. Relevant for all citizens.

**(Intermediate) Digital skills** refer to basic digital skills, media creation, problem-solving, computational thinking and coding, fundamentals of data analysis, AI, robotics, and Makerspace activities. It may also include digital entrepreneurship skills, including starting and running an online business and using digital tools to run any business. Related cognitive domain skills focus on analysis, evaluation, and creation. Relevant for secondary schools and HEIs.

**(Advanced) Digital skills** refer to skills needed by specialists in ICT professions, such as computer programming and network management, including advancing the digitalization of education systems. These include applications of advanced computational thinking, cutting-edge technologies like AI and big data, coding, cybersecurity, the IoT, mobile app development, and related transversal skills.

**Education technology (EdTech)** refers to the combination of ICT products and services to facilitate and enhance learning.

**Enterprise architecture** refers to a coherent, integrated ‘blueprint’ to optimize the often-fragmented legacy of processes (both manual and automated) into an integrated environment that supports service delivery while being responsive to changes. It provides a common vocabulary to discuss implementation across entities. This includes the overall design of a computing system and the logical and physical interrelationships between its components in reference to computers, software, or networks. The architecture specifies the hardware, software, access methods, and protocols used throughout the system.

**Electronic data infrastructure** refers to the structure and interaction of the major data types and sources, including logical and physical data assets and related data management resources. Data quality (adequacy, accuracy, relevance, explanatory capacity), data flows, storage, protection, standards, interoperability, foundational data such as IDs, birth registries, and so on are often important enabling factors. Electronic education records or any other data assets capture information regarding a child/teacher/parent’s engagement with the education system.

**E-governance** refers to the use of emerging ICT to facilitate the processes of government and public administration. It is about providing citizens with the ability to choose the manner in which they wish to interact with their governments and the choices governments make about how ICT will be deployed to support citizen choices.

**Integration** refers to the process of linking independently designed applications to work together as one system so that the data contained in each become part of a larger, more comprehensive system that quickly and easily shares data when needed. Integration enables access to data and functionality from such independent applications through a single interface or service.

**Interoperability** refers to the ability to share information and services. Defining the degree to which the information and services are to be shared is a useful architectural requirement, especially in a complex organization and/or extended enterprise. This enhances the ability of organizations to interact toward mutually beneficial goals by means of the exchange of data with other systems using common standards. Interoperability also includes the ability of systems to provide and receive services from other systems and to use the ser-



vices so interchanged to enable them to operate effectively together.

**Interoperability framework** refers to an agreed approach of interoperability for entities that wish to work together toward the joint delivery of public services (without integrating all of their subsystems into one large system).

**Microservices architecture** refers to a type of application architecture where the application is developed as a collection of services. It provides the framework for independently developing, deploying, and maintaining microservices architecture diagrams and services. Each microservice is a single service built to accommodate an application feature and handle discrete tasks. Each microservice communicates with other services through simple interfaces to solve business problems. This allows for greater adaptability and flexibility and improves fault isolation.

**Mobile apps.** The term ‘app’ has evolved to specifically connote software designed to reside on a mobile platform such as a tablet or mobile phone. It encompasses a user interface that interoperates with web-based resources that provide access to a wide array of information relevant to the app and local processing capabilities that collect, analyze, and format information in a manner best suited to the mobile platform. Additionally, a mobile app provides persistent storage capabilities within the platform. Mobile apps are generally downloaded from application distribution platforms operated by the owner of the mobile operating system.

**Procedures** refer to the steps that define the specific use of each system element or the procedural context in which the system resides.

**Socioemotional skills** refer to noncognitive, soft, or character skills, which are foundational human capabilities involved in achieving life goals, interacting with others, and managing emotions.

**Open Educational Resources (OER).** OER are teaching, learning, and research materials intentionally created and licensed to be free for the end user to own, share, and, in most cases, modify. OERs are designed to reduce accessibility barriers by implementing best practices in teaching and to be adapted for local unique contexts.

# Annex 2

## SAMPLE GPT-4 OUTPUT

*This response was generated using the latest GPT-4 model with web browsing enabled on May 22, 2023. The model generated, consolidated, and improvised the response within 2–4 minutes. The output is not fully representative of country programs and their particularities or fully accurate. This is purely to be treated as an early demonstration example of the capability of large language AI models.*

**PROMPT 1:** The contextual conditions for the readiness of education systems for digital transitions relate to five pillars. This includes (i) strategic leadership and governance for citizen-centered service delivery, (ii) better and relevant data and technology infrastructure and management, (iii) digitally enabled education service delivery and analytics to inform education sector institutions in going digital, including up-to-date education programs, curricula, and inputs, (iv) education workforce capacity and culture, and (v) financing and innovation ecosystem for enabling value-based and rights-based digital innovations in education to test, iterate, and scale. Can you provide at least 5–8 real and recent examples of actions and readiness in LIC, LMIC, MICs, and HICs in each of the above? Provide this in the form of a comprehensive table. Include sources and citations. Thank you.

**PROMPT 2:** Regenerate the above tables by combining the responses. Do not draw three columns for LIC, LMIC, and HIC; instead, suffix the example with the terms LIC, LMIC, MIC, and HIC in brackets.

**RESPONSE:** Absolutely. Here is the combined table, with examples of readiness and actions related to digital transitions in the education systems. The examples are suffixed with the type of the country (LIC, LMIC, MIC, HIC):

Area of Readiness	Examples
Strategic Leadership and Governance	Rwanda's Smart Rwanda 2020 Master Plan advances ICT in education (REB, 2020) (LIC). Viet Nam's Ministry of Education and Training launched the "Digital Transformation Program," embedding ICT in all education activities by 2025 (Vietnamnet, 2020) (LMIC). South Africa's Department of Basic Education (DBE) has an e-Education Strategy integrating digital technology into education (DBE, 2020) (MIC). Uganda's Digital Uganda Vision 2040 framework enhances digital infrastructure in rural areas (ICTA, 2020) (LIC). Singapore's ICT Masterplan promotes digital learning and equips students with digital literacy skills (MOE, 2020) (HIC).
Data & Technology Infrastructure	Brazil's NEP includes provisions for improving ICT infrastructure in schools (INEP, 2020) (MIC). Korea's National Information Society Agency (NIA) provides broadband access to all schools, supporting digitally enabled education (NIA, 2020) (HIC, EAP). Sweden's Broadband Strategy ensures fast and reliable internet access nationwide, benefiting schools (PTS, 2020) (HIC, Europe).
Digitally Enabled Education Service Delivery & Analytics	Kenya's DLP delivers digital devices to primary schools and trains teachers in digital literacy (DLP, 2020) (LIC). India's National Digital Library offers students digital educational resources (NDL, 2020) (LMIC). Indonesia's "Merdeka Belajar" initiative leverages analytics to personalize learning experiences ( <a href="https://tempo.co">Tempo.co</a> , 2020) (LMIC). China's "Internet Plus" initiative uses big data analytics to inform policy decisions and improve education service delivery (CGTN, 2020) (MIC). Canada's e-Learning Strategy promotes the use of technology and data to improve education outcomes (GOC, 2020) (HIC, Americas).

Area of Readiness	Examples
<b>Education Workforce Capacity &amp; Culture</b>	Burkina Faso's Can't Wait to Learn project uses digital tools to deliver quality education in conflict-affected areas, training teachers on their use (War Child Holland, 2020) (LIC). Pakistan's DigiSkills Training Program equips teachers with digital skills (DigiSkills, 2020) (LMIC). Thailand's "Equitable Education Fund" (EEF) provides teacher training to improve digital literacy and pedagogical skills (EEF, 2020) (MIC). Australia's Digital Literacy School Grants program supports teacher training in digital technologies (DESE, 2020) (HIC).
<b>Financing and Innovation Ecosystem</b>	Ethiopia's Digital Ethiopia 2025 strategy has secured international financing to improve digital innovation in education (World Bank, 2020) (LIC). The Philippines' DOST-SEI offers scholarships for innovation and ICT programs (DOST-SEI, 2020) (LMIC). Colombia's Ministry of Information Technologies and Communications (MINTIC) provides grants to support digital innovation in education (MINTIC, 2020) (MIC). UK's Innovate UK provides funding for digital innovation in education (UKRI, 2020) (HIC).

## References:

1. Rwanda Education Board (REB). (2020). Smart Rwanda 2020 Master Plan.
2. Vietnamnet. (2020). Ministry of Education and Training launches digital transformation program.
3. Department of Basic Education (DBE), South Africa. (2020). e-Education Strategy.
4. Information and Communication Technology Authority (ICTA), Uganda. (2020). Digital Uganda Vision 2040.
5. National Digital Library of India (NDL). (2020). NDL services.
6. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP), Brazil. (2020). National Education Plan (NEP).
7. Digital Literacy Program (DLP), Kenya. (2020). Digital Learning Program.
8. [Tempo.co](#). (2020). Merdeka Belajar.
9. CGTN. (2020). China's Internet Plus Education Strategy.
10. War Child Holland. (2020). Can't Wait to Learn Project.
11. DigiSkills Training Program, Pakistan. (2020). Digital skills for teachers.
12. Equitable Education Fund (EEF), Thailand. (2020). Teacher training program.
13. World Bank. (2020). Digital Ethiopia 2025.
14. Department of Science and Technology - Science Education Institute (DOST-SEI), Philippines. (2020). Scholarships for innovation and ICT.
15. Ministry of Information Technologies and Communications (MINTIC), Colombia. (2020). Grants for digital innovation in education.
16. Ministry of Education (MOE), Singapore. (2020). ICT Masterplan.
17. National Information Society Agency (NIA), South Korea. (2020). Broadband for Schools.
18. Post and Telecom Authority (PTS), Sweden. (2020). Broadband Strategy.
19. Government of Canada (GOC). (2020). e-Learning Strategy.
20. Department of Education, Skills and Employment (DESE), Australia. (2020). Digital Literacy School Grants.
21. UK Research and Innovation (UKRI). (2020). Innovate UK funding.



This work, *Digital Pathways for Education: Enabling Greater Impact for All*, aims to offer a strategic approach to policymakers when undertaking digital transformation reforms in education and skills development systems, with a focus on “how.” It builds on the World Bank Education Vision Framework offered in *Realizing the Future of Learning* by unpacking the cross-cutting area of “Invest wisely in technology,” looking into how this may be done to maximize impact at scale for all. We promote cautious optimism and techno-realism, clarifying how the education and skills sectors can use digital technologies to their advantage by being proactive, strategic and evidence-based, considering carefully why to use digital and in what conditions the existing and emerging technologies might be positively leveraged. It is widely recognized that one size does not fit all and that policymakers need to have a laser focus on learning, weighing in contextual needs and purposefully using the next marginal investable dollar on digital solutions to fulfill education objectives equitably at scale for all. Along with policymakers in government who are the primary audience for this work, it is intended to enable dialogue and critical partnerships across industry, academia, researchers and multilaterals, and World Bank staff to support and deepen our country engagements as countries increasingly expand the digital reach of public education services.

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