HOW MUCH DOES UNIVERSAL DIGITAL LEARNING COST?

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POLICY BRIEF

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Key messages

- Investing in universal digital learning is crucial to achieving Sustainable Development Goal 4: to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- The COVID-19 pandemic revealed that to make education systems more resilient requires significant progress on digital learning, both for remote learning – when schools are closed – and for blended learning in classrooms.
- Based on the conceptual framework of the Reimagine Education initiative,[2] it is estimated that US$1.4 trillion is needed for the universalization of digital learning for the 2021-2030 period:
  - US$410 billion for universal electricity
  - US$428 billion for universal internet connectivity
  - US$498 billion for making data usage affordable (zero-rating), and
  - US$46 billion for the recurrent delivery of digital learning.[3]
- With strong political will and support from governments and donors as well as multi-sectoral commitment and public–private partnerships, this substantial (or large) amount is within reach.
- Swift action – starting with a focus on the most deprived children – is vital to ensure that ongoing digitalization acts as an equalizer of learning opportunities rather than a driver of disparities. This requires collecting disaggregated data to help all stakeholders understand (the cost to cover) the needs of children marginalized by disability, poverty, ethnicity, gender, geography and situations of conflict or humanitarian crises.

Introduction: why digital learning, why universal and why costing

The universalization of digital learning, as a tool for blended learning in classrooms as well as for remote learning when classes are closed, is an important investment toward establishing more resilient and sustainable education systems (UNICEF, 2021). Throughout this paper, digital learning is broadly defined as learning conducted via a digital device.[4] The digital learning costed in the paper focuses on children and young people, who comprise the target group for the Reimagine Education initiative co-led by UNICEF, Generation Unlimited and Giga to radically scale up digital learning solutions that will work for the most marginalized children and young people (UNICEF, 2020b).

With the onset of the COVID-19 pandemic, digital learning, alongside other remote learning solutions such as TV and radio programmes and paper-based take-home learning packages, became essential for many governments, schools and families. The digital learning strategies developed during this time have been a step toward building preparedness and resilience for future crises requiring school closures. According to the second round of the joint UNESCO/UNICEF/World Bank Survey on National Education Responses to COVID-19 (UNESCO, UNICEF and World Bank, 2020), two thirds of governments have created their own platforms to display educational content for teachers and students in primary and secondary education, supplemented by commercial and open-source platforms.

Extra efforts are needed to ensure that digital learning is universalized and to minimize risks of increasing existing learning disparities (Brossard et al., 2021). Universalization does not mean that everyone must conduct digital learning, but rather that everyone should have access when needed, such as during a national lockdown. Several important gaps must be filled before universalization can be achieved. For example, digital learning is impossible without electricity, and in some countries like Chad, the Democratic Republic of Congo, Malawi and Niger, the proportion of the population with access to electricity is below 20 per cent.[5] Digital learning also requires connectivity. When schools were closed globally during the COVID-19 pandemic, more than 75 per cent of children were not reached by available digital learning opportunities, three quarters of whom come from the poorest 40 per cent of households (UNICEF, 2020a). The coverage and effectiveness of digital learning solutions also vary significantly across countries, to the detriment of the low- and lower-middle-income countries and to the poorest households within all countries (GEMR, 2020).

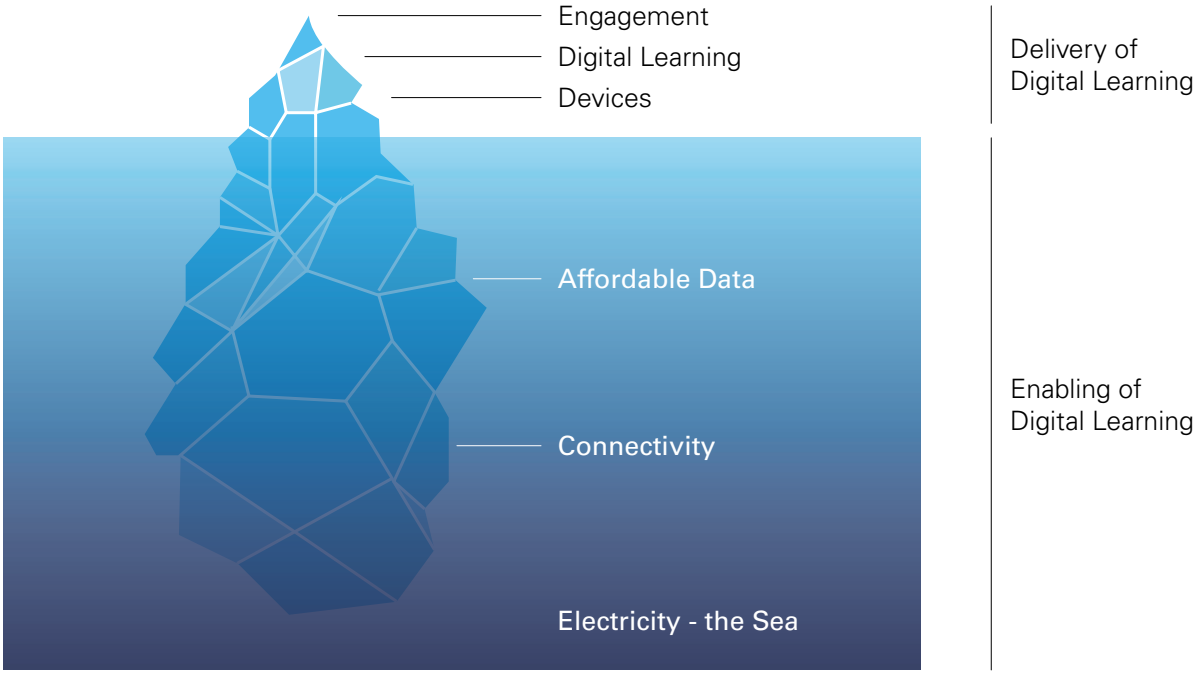
Estimating the cost to universalize digital learning is one hurdle, with financing an even more significant challenge that is exacerbated by the limited fiscal space brought about by the economic downturn and increases in spending on health and social protection. The latest estimate shows that the gap in annual funding needed to reach the Sustainable Development Goal in education (SDG4) in low- and lower-middle-income countries has increased from US$148 billion pre-COVID to nearly US$200 billion post-COVID, i.e., a total funding gap of nearly US$2 trillion for the next 10 years (UNESCO, 2020b).

In light of the above concerns, this paper estimates the cost of the universalization of digital learning by 2030, in alignment with the conceptual framework of the Reimagine Education initiative.[6] This paper opens with a discussion of cost items for universal digital learning, which are broadly classified into the cost of (a) enabling digital learning and (b) delivering digital learning. The paper then provides a rationale for the cost assumptions used and gives related cost estimations on each.[7] It also discusses financing achievability by comparing the estimated costs with current spending in education and other relevant sectors.

What is costed?

Digital learners need to be able to access and use digital content through appropriate devices. Imagining the provision of digital learning as an iceberg (*see Figure 1*), devices, digital solutions and engagement will be the three items above the surface of the sea, since they are more visible to educators and learners.

Figure 1. Items to be costed for the universalization of digital learning



Aligning to the Reimagine Education framework, these can be further categorized as:

- Purchase and maintenance of devices for children and young people;
- Purchase and maintenance of devices for teachers and facilitators;
- Pedagogical content that includes identifying, curating and scaling up digital solutions;
- Upskilling teachers and facilitators in digital learning and pedagogies;
- Building policy and institutional capacity;
- Supporting data, analytics and research on the design and implementation of digital learning solutions; and
- Engaging the public, especially young people, for advocacy, scaling up, accountability, etc.

Internet connectivity and affordable learning-related data usage comprise the part of the iceberg beneath the sea. These enabling factors, or the wider ecosystem, will require substantial cross-sectoral investment, but in return can benefit multiple sectors in addition to education. Though less perceptible to educators and learners, they are critical components of successful digital learning and complete the five pillars of the Reimagine Education initiative. Digging deeper, access to electricity can be thought of as the sea itself, because without access to electricity digital learning cannot even be an option. The same way an iceberg cannot exist without water, digital learning cannot take place without a power supply, which is still not accessible for millions of the most vulnerable people, including half of the population in sub-Saharan Africa. A prerequisite for universal digital learning is universal access to electricity. The following sections elaborate on the estimated cost of enabling and delivering digital learning.

Costing 'enabling' of digital learning: electricity, connectivity, and affordable data

According to the International Energy Agency (IEA, 2019) and Sustainable Energy for All (SEforALL, 2020), an investment of US$410 billion (US$41 billion per year) will be required to achieve universal **electricity** access by 2030.[8] Half of the investment, US$205 billion, is needed in sub-Saharan Africa, while South Asia needs US$153 billion (SEforALL, 2020).[9] Without sufficient investment, based on current trends, access to electricity is projected to gradually

grow from 90 per cent in 2018 to about 94 per cent in 2030, which means that close to 620 million people, mostly living in low-income, remote, or conflict-affected countries would still have no access (IEA et al., 2020). For countries that currently have extremely low electricity access rates, digital learning will hardly be on the agenda without further electrification. Note that the recurrent cost of electricity usage for digital learning purposes will be minimal compared to the cost of infrastructure and is assumed to be part of the device cost in the next section.

Next, according to the International Telecommunication Union (ITU) (2020), US$428 billion is required to achieve universal access to broadband internet **connectivity** by 2030.[10] A large share of spending, US$125 billion, is needed for South Asia, followed by US$82 billion for East Asia and Pacific, and US$54 billion for Eastern and Southern Africa. This means a marginal cost of US$114 per person to connect everyone everywhere. The total amount includes US$288 billion investment by the private sector and US$94 billion by the public sector on infrastructure, which covers the capital expenditure on mobile infrastructure, metro and backbone fibre, network operation and maintenance, and remote area coverage. In addition, public spending of US$46 billion is needed for relevant policy and regulation as well as necessary information and communication technology (ICT) skill building and content development (A4AI, 2020a).

Finally, based on the affordability index[11] compiled by the Alliance for Affordable Internet (A4AI) (2020a) following the UN Broadband Commission's '1 for 2' affordability threshold (which refers to having a cost for 1GB data not higher than 2 per cent of average monthly income), a subsidy or fee decline equivalent to US$498 billion is needed to ensure **affordable data usage** in learning activities for the coming decade.[12]

In sum, it is estimated that US$1.34 trillion is needed in the form of investments and subsidies to enable the universalization of digital learning by 2030. This cost could be lower if there is a breakthrough in the productivity of related hardware and equipment. It includes a US$410 billion investment in electricity access, US$428 billion in spending on connectivity, and zero-rating of data usage worth US$498 billion. In the next section, the cost estimates more directly associated with the recurrent operationalization of digital learning are made, under the assumption that the investment in these enabling factors will be realized.

Costing 'delivery' of digital learning: devices, digital solutions, and engagement

The investments needed for the delivery of digital learning – devices, digital solutions and engagement – are significant but much smaller compared to the capital-intensive investment in electricity and connectivity. See more details about the calculation and disaggregated results in Annexes B and C.

Devices

The global cost of devices (purchase and maintenance) is estimated at US$38 billion for the 2021–2030 period, of which about US$36 billion would be spent on **devices for children and young people** and US$2 billion on **devices for teachers and facilitators**.[13] A digital learning device can be a phone, tablet, laptop, desktop computer or other digital equipment such as a digital whiteboard for use in the classroom. The estimate of total cost depends on device cost and the number of people in need.

Digital solutions

For each country, the cost of digital solutions mainly encompasses the costs of learning/educational content, upskilling teachers/facilitators, building policy and institutional capacity, and supporting data, analytics and research on the design and implementation of digital learning solutions. They add up to US$7.1 billion for the 2021-2030 period and are distributed as follows: US$2.4 billion for **content,** US$3.1 billion for **upskilling** teachers and facilitators in digital learning and pedagogies, US$200 million for **building policy and institutional capacity**, and US$1.4 billion **supporting data, analytics and research**. More details are provided in Annex B.

Engagement

In digital learning, young people hold the dual roles of beneficiaries and agents of change thanks to their readiness for the digital age — youth are 50 per cent more likely to be online compared to the whole population (ITU, 2017). Some young people may be junior teachers in the school system and/or parents/caregivers of young children. Young people can be instrumental in bringing digital learning to scale, making it relevant for users, and ensuring that it reaches the most marginalized. They also have a natural inclination to volunteer for their communities, and appropriate investment can amplify their reach and the effectiveness of their engagement. The Reimagine Education initiative has categorized young people's digital learning engagement into access, reach, advocacy & resource mobilization, content, and voice & accountability (UNICEF, 2020c), with a list of activities such as managing after-class learning groups whose participants share a limited number of devices, conducting youth-led marketing campaigns, volunteering in localized content development and translation, and sharing views and opinions on platform improvement. UNICEF's 2019 spending on education-related Adolescent Development and Participation (ADAP) in active countries averaged US$3.5 million, with variation.[14] As in the case of data and analytics, the costs of engagement range between US$3-10 million at country level, aggregated to US$1.4 billion at global level for the 2021-2030 period.

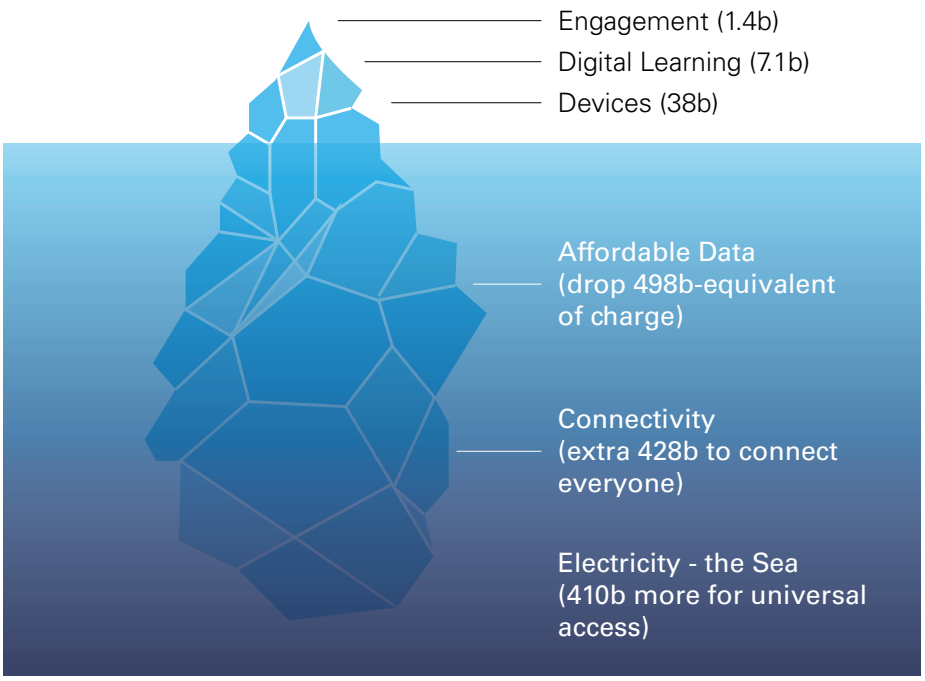
Financing achievability

Within the coming decade (by 2030), it is estimated that it will take US$1.34 trillion to enable and US$46.4 billion to deliver the universalization of digital learning (*see Figure 2*).[15] This section discusses financing achievability of this cost through the use of comparisons and realistic assumptions.

For electricity, the annual investment of US$41 billion for universal access is equivalent to 3 per cent of the US$1.36 trillion global energy investment per year needed to achieve SDG7, i.e., 'Ensure access to affordable, reliable, sustainable and modern energy for all' (IEA, 2019), which also includes additional funding for clean cooking, renewable energy and energy efficiency.

For connectivity, US$428 billion by 2030 is itself the total cost of connecting all of humanity to the internet (ITU, 2020b). Spending this entire amount would connect not only schools but also other locations where digital learning can take place. It is estimated that two thirds of this cost could be

Figure 2. How much it will cost to achieve universal digital learning by 2030



46.4 billion to Deliver
(4.6 billion per year, equivalent to <1% of the public education spending)

1.34 trillion to Enable
(134 billion per year, equivalent to 3% of the energy investment + 5% of the telecom market revenue)

covered by private investment, as connectivity is a profitable investment. For data affordability, a subsidy of and/or zero-rating estimated at US$49.8 billion per year is equivalent to only 2.9 per cent of the US$1.74 trillion global telecom service market in 2019 (GVR, 2020), and thus is potentially achievable.

Finally, for the 'delivery' of digital learning (devices, digital solutions and engagement), the annual cost of US$4.6 billion accounts for only 0.1 per cent of the US$4 trillion [16]of global public education spending.[17] Such a comparison might, however, be unfair, since a large proportion of public education spending takes place in upper-middle- and high-income countries, while for digital learning each year US$3.2 billion out of US$4.6 billion is for low- and lower-middle-income countries. For these countries, the annual US$3.2 billion accounts for 0.8 per cent of the public education spending, which still seems feasible if there is a political will and increased support from the international community.

Conclusion

It is estimated that US$1.4 trillion will be needed in the coming decade to provide every child and young person with access to digital learning.[18] Although this is a sizeable investment, it accounts for only small shares of the current investment in electricity, revenue in telecoms and public spending on education.

Hence, the related financing is achievable if there is strong political will and support from governments and donors as well as multi-sectoral commitment and public–private partnerships. It is worth noting that efforts have already been made in that direction, such as the agreement signed between UNICEF and mobile network operators on zero-rating digital educational content that will span 94 countries and 1.8 billion subscribers (UNICEF, 2020c).

A next step for this costing exercise is to collect more disaggregated data. This is critical for all stakeholders to understand (the cost to cover) the needs of children marginalized by disability, poverty, ethnicity, gender, geography and situations of conflict or humanitarian crises. Education actors must ensure the ongoing digitalization acts as an equalizer of learning opportunities rather than a driver of disparities.

Endnotes

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1. The authors would like to thank Akihiro Fushimi, Alassane Ouedraogo, Frank Van Cappelle, Ingrid Sanchez Tapia, Jutaro Sakamoto and Sarah Fuller of the UNICEF Education team and Network of Education Results and Data Specialists (NERDS), Fabio Friscia and Linda Jones of the UNICEF Education and Adolescent Development Group, Jaime Archundia of the UNICEF Office of Global Innovation, Jennifer Asman of the UNICEF Social Policy team, Marta Carnelli and Thomas Wells Dreesen of Office of Research, Alex Twinomugisha of the World Bank, and Sonia Jorge of the Alliance for Affordable Internet, who reviewed and/or provided valuable insights to this paper and/or the costing tool, and Nancy Vega of UNICEF Education for copyediting. The authors would also like to thank Robert Jenkins (UNICEF Education and Adolescent Development Director) and Gunilla Olsson (UNICEF Innocenti Director) for their great guidance and continued support. The findings in this paper were used by the Reimagine Education Summary Case for Investment and the Action Memo on Digital Learning for All.

2. Reimagine Education is co-led by UNICEF, Generation Unlimited and Giga. Giga is an initiative launched by UNICEF and ITU in September 2019 and whose goal is to connect every school to the internet and every young person to information, opportunity and choice.

3. On the cost estimate for delivery, which includes the purchase and maintenance of IT devices, the delivery of digital learning solutions and engagement and advocacy activities, an Excel tool was further developed to allow for more customized costing at country level. See Annex A.

4. his definition mimics the broad definition of e-learning available in the Oxford English Dictionary – learning conducted via electronic media. The term 'digital' excludes learnings through 'analog' radio or TV, which are still in use in many lower-income countries, from digital learning.

5. World Bank, 'Access to electricity, % of the population', <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS>

6. The macro-level costing done in this paper complements other emerging meso- or micro-level costing toolkits that are applicable to digital learning and require more tailored manual input, such as the UNICEF human-centred design toolkit (UNICEF, AKF and IU-AKES, 2020a, 2020b) built on the understanding of effective EdTech investments (IU-AKES and AKF, 2018), and the World Bank template for costing remote learning encouragement built on the practices of five projects that it sponsored (Holla and Pan, 2020).

7. With more focus on the costs of delivering, which are less covered by literature but can be calculated at not only global but also country level.

8. See elaboration of calculation in Annex B.

9. Since the estimate was made before accounting for COVID-19 effects, the actual amount could be higher.

10. In other words, to roll out and maintain 2.6 million 4G base transceiver stations and 700,000 km of backbone fibre transmission infrastructure on top of the existing broadband network capabilities.

11. An affordability index is a measure of an average person's ability to purchase a particular item. The affordability index as of 2020 indicates that globally, data usage cost represents 2.45 per cent of average monthly income in low- and middle-income countries.

12. Assuming that high-income countries have already met the threshold, and that 1GB per month is needed for a typical nine-month school year's learning-related data usage, international agencies, governments, telecom service providers and learning platforms need to work together to erase a charge equivalent to 0.45 per cent (2.45 minus 2) of the national income in low- and middle-income countries. This seeks to save US$49.8 billion in data charges for the users per year, or US$498 billion by 2030, through subsidies and zero rating. See more details in Annex B.

13. A facilitator refers to a parent or caregiver for young children who have not reached school age, and teaching personnel or volunteers supporting the transition back to learning for out-of-school children and people in humanitarian situations.

14. Figures extracted from and calculated on the UNICEF prorated expenditure under Goal Area of 'Learn'.

15. For each year (divided by 10), that will be approximately equal to Verizon's 2019 revenue for enabling, and Costa Rica's 2019 government education expenditure for delivering.

16. Calculations based on Al-Samarrai et al. (2019) and World Bank World Development Indicators; the global GDP in 2019 is 87 trillion, so 87 x 0.045 = 3.95 trillion.

17. Education programmes differ from infrastructure projects such as electricity and telecoms, which have the potential to attract private and foreign investment. Also, the annual global education development assistance will float between only US$14 billion and US$16 billion in foreseeable years (UNESCO, 2020a), which can hardly fill the US$200 billion post-COVID annual funding gap in low- and lower-middle-income countries (UNESCO, 2020b), let alone be channelled to support digital learning. Therefore, these countries are expected to rely mainly on domestic resources and to leverage public–private partnerships to deliver digital learning.

18. It is worth noting that the costing in the paper, as well as existing tools, all rely on pre-COVID knowledge and data. Intuitively the pandemic may be accelerating connectivity, device and digital solutions while decelerating electrification, affordability and engagement in 2020, but more data and evidence are needed to make conclusions. The refinement and synergy of the different costing tools is then also recommended for supporting a quality expansion of digital learning.

19. See footnote 1 for the experts reached.

20. This means a marginal cost of under US$26 to reach a child or young person who was previously offline, or a spending of US$14 per capita serving all children and young people regardless of existing access to device and internet. See above for the estimate of 1.8 billion people in need – 46.4 divided by 1.8 is under 26; and since the content of digital learning discussed in this paper is a public good, it can also reach those already accessing digital learning – for the 3.5 billion children and young people targeted by the Reimagine Education initiative, 46.4 divided by 3.5 is under 14.

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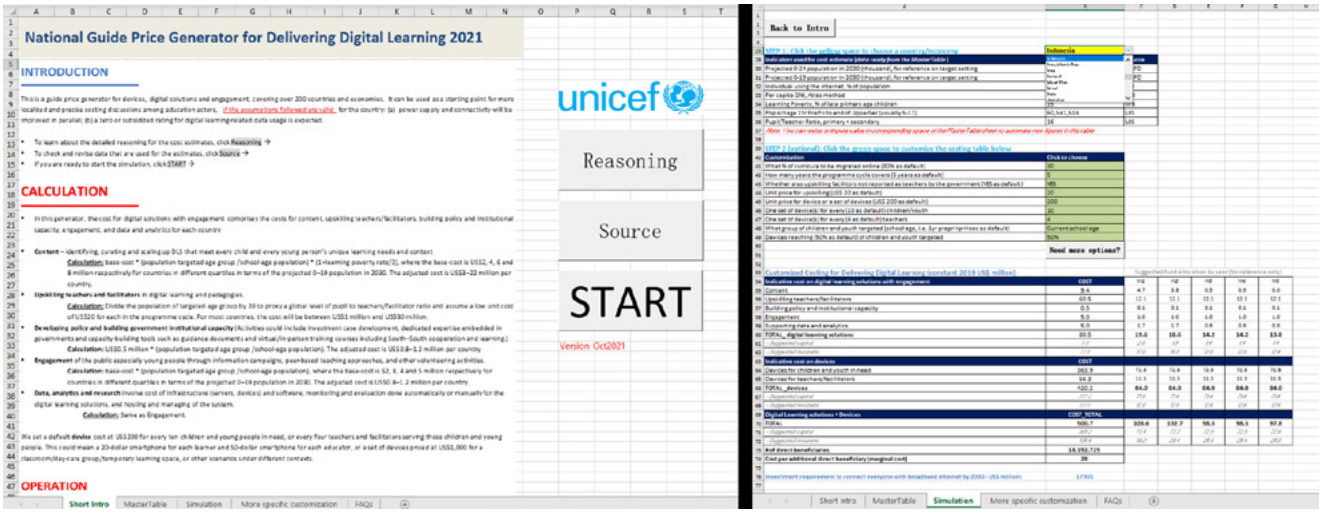
ANNEX A

EXCEL TOOL TO GENERATE GUIDE PRICE FOR DELIVERING DIGITAL LEARNING AT COUNTRY LEVEL

Since the estimate of the cost of delivering digital learning (devices, digital solutions, engagement) relies on widely available and frequently updated country-level indicators, it enables estimates of 'guide prices' for over 200 countries and economies. The linked Excel tool generates costing tables through simple clicks and allows certain customizations such as level of digitization of the curriculum and unit cost of upskilling.

With one click selecting a country or economy, a default output table will be automated, and with the nine optional clicks on customization, 38,400 output tables are possible for each country or economy. The generated cost can serve as a starting point for more localized and precise costing assuming that electricity, connectivity, and data affordability will also be improved in parallel.

How much will it cost in your country?



ANNEX B

DETAILED METHODOLOGY AND ASSUMPTIONS USED FOR THE CALCULATION

Costed item	Additional rationale behind estimates and calculations
Electricity	• According to IEA, 2019, US$1.36 trillion per year is requested to achieve all targets of SDG7, i.e., 'Ensure access to affordable, reliable, sustainable and modern energy for all', which includes 40 billion on electricity access, 5 billion on clean cooking, 690 billion on renewable energy and 625 billion on energy efficiency. • According to the IEA (2019), there are 789 million people without access to electricity. 410/0.789=520.
Connectivity	• More precisely, the US$428 billion includes 104 billion on mobile infrastructure CAPEX, 70 billion on metro and backbone fibre, 140 billion on network operation and maintenance, 70 billion on remote area coverage, 6 billion on policy and regulation and 40 billion on ICT skills and content. • According to ITU statistics on access to internet for year 2020, there are 3.76 billion people unconnected to internet. 428/3.76=114.
Affordable data	• For low- and middle-income countries, the gross national income per capita was US$5,093 in 2019 according to the World Development Indicator, and the under-25 population was 2.9 billion, averaging the 2021–2030 projections by United Nations Population Division (UNPD). The equation is then US$5,093 * 0.45% * 2.9 billion * (9 months / 12 months) = US$49.8 billion. • Admittedly, both the cost of and demand for data can change drastically, hence the US$498 billion is a rough estimate whose accuracy depends on the future dynamic between the decline in spending-to-income ratio and the growth in the amount of data needed for learning activities. For now, we assume that the two factors offset each other. • Larger-scale manufacturing can lead to a sharp decline in price. For example, according to Our World in Data (https://ourworldindata.org/cheap-renewables-growth), the cost of solar panels has declined by 90 per cent in a decade. On the other hand, since price is driven not only by supply but also demand, it is 'breakthrough' and not growth in productivity (supply) that can surely lower the cost. For example, the increase of supply of fibre optic cable does not necessarily mean lower prices if the demand for fibre optic cable increases, which is possible due to 5G scale-up.

Costed item	Additional rationale behind estimates and calculations
Overall on delivery (devices, digital solutions, engagement)	• Global and national cost estimates related to devices and digital solutions are not easily available. Nevertheless, it is possible to use indicators (see Table 1) and historical programming data to estimate 'guide prices' in different country contexts and then aggregate them for global estimates. **Table 1**: Major indicators used for costing of devices, digital solutions, and engagement

Major indicators used for the estimate	Source
Projected under-25 population in 2030 (thousand)	World Population Prospects, UNPD
Individuals using the internet, % of population	International Telecommunication Union
Learning poverty, % of late primary age children who cannot read a simple text	World Bank
School-age population, 1-year pre-primary to upper secondary	UNESCO Institute for Statistics
Pupil/Teacher Ratio, primary and secondary combined	UNESCO Institute for Statistics

- The costing does not include activities that should take place even without digital learning, such as teacher recruitment, curriculum reform and classroom renovation. For default calculation, certain rules, unit costs and formulas are assigned to ensure cost-efficiency, which is in response to the concern over the widening education funding gap at the global level (UNESCO, 2020b). The Excel tool in Annex A displays detailed calculations and provides adjustable parameters that allow more customized cost estimates at country level.
- To simplify the estimate, two default rules are applied to all items. First, we assume each country will spend a time period equivalent to five years in the coming decade to conduct digital learning for all eligible children. This accommodates the reality that many countries do not currently have the necessary enabling factors (electricity access, connectivity, and affordable data) and thus will need time to universally provide digital learning. Also, in this case, device replacement will not be costed and some of the digital solutions items can be estimated by multiplying the annual cost by five. Second, for each item, our estimate will first focus on school-age children (one-year pre-primary plus primary and secondary school age) due to better availability of literature, data and programming experience for the group, then expand proportionally to the population ratio to cover the entire under-25 population. In other words, we assume the same per capita marginal cost between school-age children, youth and young children.

Costed item	Additional rationale behind estimates and calculations
Devices	• Through consultation with experts,[19] default device cost was estimated at US$20 for each leaner reached, and US$50 for each teacher or facilitator. According to A4AI (2020b), US$20 per learner is a 'frugal' scenario that matches the price of the least expensive smartphone in use in Guinea, Jamaica, Lesotho, Liberia and Mozambique, while US$50 is about the median smartphone price in low- and middle-income countries. This set of unit cost could mean a set of devices priced at US$1,000 for a classroom/day-care group/temporary learning space, or a US$20 smartphone for each learner and a US$50 smartphone for each educator when getting together is not possible, or IN other scenarios under different contexts. For simplification, we also assume that the administration, logistics and utility are reflected by the current unit cost. • Regarding the number of people in need, we use the ITU indicator of '% individuals using the internet' in 2017–18 to estimate the proportion of people with/without access to a device. Children and young people without internet access, regardless of schooling status, are considered in need of device provision. Defined as 'used the Internet (from any location) in the last 3 months' (ITU, 2020a), this indicator is an optimistic proxy for the rate of device usage but could be a reasonable proxy to the average usage rate for the period 2021–30. Applying the values to each country's latest pupil-teacher ratio and projected under-25 population in 2030, there are 1.8 billion children and young people plus 40 million teachers and facilitators to be targeted for device provision. It is worth noticing that, for the worst (also unlikely) scenario with everyone studying from home and household internet access unchanged, two-third or 2.2 billion of children and young people are in need (UNICEF and ITU, 2020).
Digital solutions – content	• If we reference cost discussion in high-income countries: Assuming 1,000 learning hours per year, US$5,000 per hour of online-ready learning content, and at least 30 per cent of the curricula to be digitized, the estimated cost could be US$18 million per country for primary and secondary education, typically taking 12 years. Examples of digital content costs can be found (Example 1, Example 2, Example 3). Proportionally expanding the coverage to serve all under-25 population, i.e., school-age children, youth, and parents/caregivers of young children, the cost will be high at 18m * 25yr / 12yr = US$37.5 million per country. • However, the actual amount could be much smaller if existing content resources/digital public goods are tapped into and when there is in-country expertise. We estimated US$2.4 billion will be needed for content. This includes identifying, curating and scaling-up digital solutions that meet individual learning needs and context, i.e. that are age appropriate, in languages that children can understand, and that the content will build the broadest range of skills. Assuming 30 per cent of curricula digitized, which is the lowest threshold for a learning to be considered as blended (Allen, Seaman and Garrett, 2007), our model started with low initiating costs of US$2, 4, 6 and 8 million for school-age population based on the quartile of school-age population a country falls in, which was then extended proportionally to the age-group population ratio to cover all children and young people, and the estimate further adjusted for the learning poverty rate. Here a learning poverty adjustment refers to multiplying the obtained estimate with '1+learning poverty rate/2' to reflect the extra effort needed to assure digital learning access and quality in countries with higher learning poverty, and to echo the target of halving the global learning poverty rate by 2030 (World Bank, 2019). This equation results in a cost of US$3 million and US$22 million per country, aggregated to US$2.4 billion at a global level.

Costed item	Additional rationale behind estimates and calculations
	• Learning poverty rate is defined as the percentage of 10-year-old children who cannot read and understand a simple story, and it can serve as a proxy for the situation of access and learning in the education system. The indicator brings together schooling and learning indicators: it begins with the share of children who haven't achieved minimum reading proficiency as measured in schools and is adjusted by the proportion of children who are out of school and are assumed to be unable to read proficiently. All skills are important, but the quality part of learning poverty rate focuses on foundational reading because: (i) reading proficiency is an easily understood measure of learning; (ii) reading is a student's gateway to learning in every other area; and (iii) reading proficiency can serve as a proxy for foundational learning in other subjects, while foundational learning affects learning outcomes at all age groups. • While there could be other constructions of the multiplier, the one used (1+learning poverty rate/2) is relatively moderate with a theoretical ceiling of (1+1/2) = 1.5. Mathematically, a multiplier of '(1- learning poverty rate/2) / (1-learning poverty rate)' can more accurately express additional investment needed to halve learning poverty. However, this construction yields radical value for countries with higher learning poverty, at the risk of confounding the extra investment needed for digital content with those for the overall system strengthening – something that should be done even without digital learning. For example, if a country has a learning poverty rate of 90 per cent, the multiplier will be high at (1-0.9/2)/(1-0.9)=5.5 following the radical formula, while at (1+0.9/2)=1.45 following the moderate formula.
Digital Solutions – upskilling	• To upskill teachers and facilitators in digital learning and pedagogies, the estimated cost is US$3.1 billion. This will be vital to ensure that teachers and facilitators can benefit from and support the learning of every child and young person. The costing assumes that an upskilled teacher or facilitator is needed for every 20 children or young people and applies a low unit cost of US$20 provided that an increasing portion of the upskilling activities will be online or self-paced when a national or regional digital platform becomes functional. For most countries, the cost falls between US$1 million and US$30 million, aggregated to US$3.1 billion at the global level. Note that this could be an underestimate due to missing data in 19 out of the 217 countries and economies, dominantly island countries and territories. The costing tool in Annex A allows imputation by country. • The progressive assumption of upskilling one teacher/facilitator for every 20 learners is to match the latest (2018) global pupil-teacher ratio reported for primary and secondary schools by the UNESCO Institute of Statistics. The ratios for pre-primary and tertiary are not referenced due to a large share of missing data. The unit cost of US$20 is a rounded figure assuming that the actual cost of a structural upskilling is about one-third of the typical certification cost in corresponding professional development. For example, Microsoft charges US$62 in low- and lower-middle-income countries for the certificate of Microsoft certified educator, and mainstream online learning platforms such as Coursera and EdX charge between US$49 and US$99 for a certification of completing a 3–4 week digital-teaching course.

Costed item	Additional rationale behind estimates and calculations
Digital Solutions – building policy and institutional capacity	• For building policy and institutional capacity, US$200 million will be needed to ensure digital learning approaches are sustainable, and to ensure that evidence-based approaches are included in Education Sector Plans and budgets. Activities include investment case development, dedicated expertise embedded in governments and capacity-building tools such as guidance documents and virtual/in-person training courses. • For each country, assuming five-years equivalent is needed to scale up digital learning, we estimate a minimum of US$500,000 (US$100,000 per year) to strengthen policy and institutional capacity to serve school-age children. Based on UNICEF's spending data, US$100,000 a year can contract a consultant to support sector planning, guideline establishment and deployment, or finance two to six formal workshops/ trainings with policymakers and education actors. Assuming that the cost to reach additional age groups (young children and college-age youth) is proportional to the sizes of group populations, the cost of covering children and young people varies between US$0.8 million and US$1.2 million at country level, aggregated to US$200 million globally. This happens to be about one year of UNICEF Education spending on system strengthening. System is a classification in UNICEF's 2014–17 Strategic Plan and so it is coded in an earlier database of expenditure. It includes activities for building policy and institutional capacity and covers multiple education topics.
Digital solutions – data, analytics and research	• In terms of supporting data, analytics and research, US$1.4 billion is needed. Timely data and evidence are essential to planning and sustainability. This includes information on which children are learning digitally, what they are learning, where they are and gaps in any of the above. Disaggregated data also needs to be collected as they will be critical to help all stakeholders understand the needs of children marginalized by disability, ethnicity, gender, geography, humanitarian situation and poverty. Research on the design and implementation of digital learning solutions is also crucial for improving their effectiveness. • The costing of this activity covers additional infrastructure and software needed and related maintenance, monitoring, evaluation and research on the digital solutions using data automation and quantitative, qualitative and implementation research. In addition, the additional cost needed for Education Management Information System (EMIS) varies across countries, as they are at different stages of their development cycle with various business, data, application, and technology architecture (Van Wyk and Crouch, 2020). Our model sets initiating costs of US$2, 3, 4 and 5 million for school-age children based on the population quartile a country falls in, then extends it proportionally to the age-group population ratio to cover all children and young people. The costs range between US$3 million and US$10 million at country level, aggregated to US$1.4 billion at global level. • It is relatively straightforward to estimate a cost based on household survey experience. By 2030, assuming five years are needed to support data and research before reaching universalization of digital learning, UNICEF's spending is on average about US$2 million per office, or US$5 million per MICS country where its major data and research works are conducted. Expenditure on data and analytics can be found with the generic intervention code of '701' in the UNICEF financial overview. It is over US$300 million for the latest five years. There are 129 UNICEF country offices, 7 regional offices and 20 global offices, and the sixth round of MICS is supposed to be completed in 61 countries in a five-year period. In the absence of a better estimate, US$2–5 million can serve as a baseline range of investment on digital learning-related data and analytics.
Engagement	• Referencing the ADAP spending, we might apply a formula for each country starting with the initial cost range of US$2–5 million depending on the size of school-age population, and then extend this proportionally to the population ratio to cover all children and young people.

ANNEX C

COST DISAGGREGATION OF THE "DELIVERY" OF DIGITAL LEARNING

Assuming available electricity, connectivity and data affordability and summing up the estimated costs of devices, digital solutions and engagement, a minimum of US$46.4 billion will be needed by 2030 to deliver digital learning for all.[20] Table 2 presents disaggregated costs by targeted coverage (all or half of the population; only school-age children or children and youth) and group of countries (low- and lower-middle-income countries only or all countries). A notable milestone is that US$31.7 billion needs to be spent on reaching children and young people in the 79 low- and lower-middle-income countries.

Figure 3 displays the cost by region. Due to their large young population not yet connected to the internet, South Asia and sub-Saharan Africa account for 60 per cent of the cost for delivering digital learning. For the US$8.4 billion needed on digital solutions and engagement, US$4.3 billion is for low- and lower-middle-income countries, with major spending on content and upskilling (see *Figure 4)*.

Targeting school-age children

	Low- and lower-middle-income Countries		All Countries	
	Cost	Additional beneficiaries	Cost	Additional beneficiaries
Halving the unconnected	9.6 billion	335 million	14.4 billion	453 million
Universal access	16.9 billion	672 million	24.4 billion	904 million

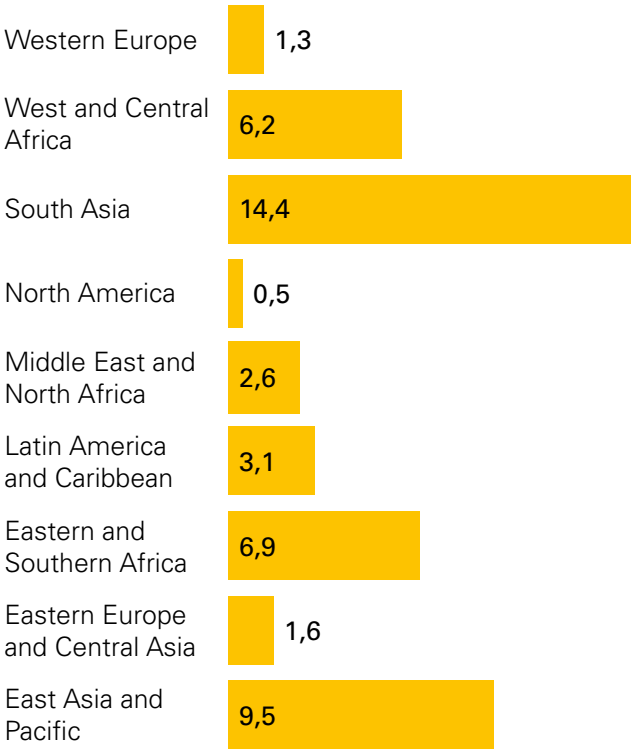
Targeting children and young people

	Low- and lower-middle-income Countries		All Countries	
	Cost	Additional beneficiaries	Cost	Additional beneficiaries
Halving the unconnected	18.0 billion	705 million	27.4 billion	925 million
Universal access	31.7 billion	1.4 billion	46.4 billion	1.8 billion

Source: Author's calculation in 2019 US$ value.

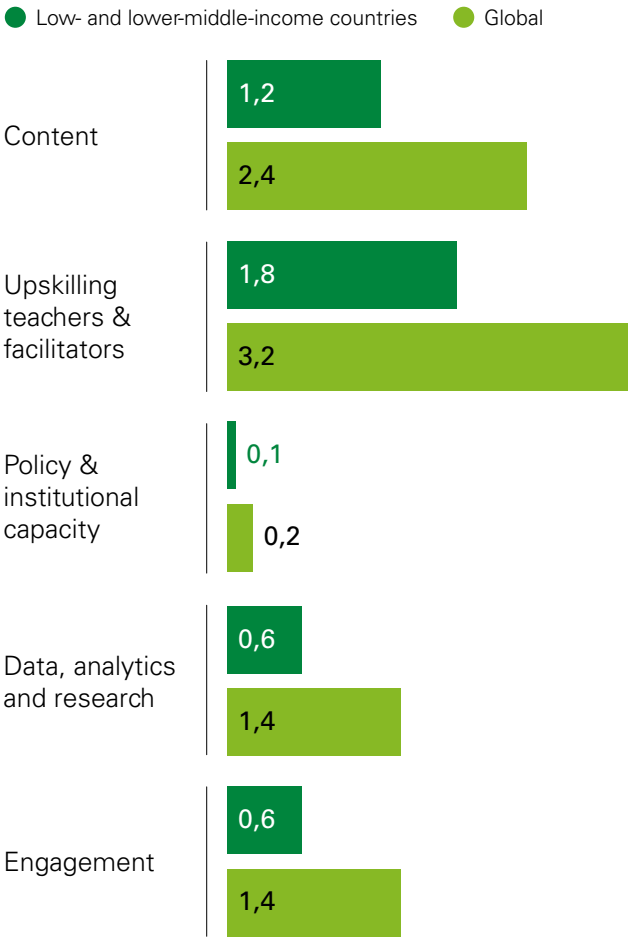
Note: School-age refers to one-year pre-primary plus official primary and secondary school age. The numbers of additional people reached are calculated from multiplying the projected 2030 population with percentage of people without access to internet in 2017–18 for corresponding age/country groups. See discussion in 'Devices' section.

Figure 3. Extra cost to 'deliver' digital learning, 2021–2030 by region (US$ billion)



Source: Author's calculation in 2019 US$ value.
Note: The disaggregation follows the definition of regions adopted by the UNICEF Division of Data, Analytics, Planning & Monitoring.

Figure 4. Extra cost of 'digital solutions' with 'engagement', 2021–2030 by item and group of countries (US$ billion)



Source: Author's calculation in 2019 US$ value.

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