

Digital Learning Cost Calculator

Technical Guidelines and Reference Parameters



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Introduction



The digital transformation is reshaping the future of education. More than a trend, the pedagogical use of technology has become a condition to promote equity and expand learning opportunities. Tools such as video lessons, adaptive platforms, digital games and real-time collaborative resources are expanding the possibilities for teaching and learning, especially in contexts historically marked by deep inequalities (Arias Ortiz et al., 2025).

Ensuring that technology integration becomes a sustainable public policy that genuinely improves learning requires more than just good intentions. It demands a clear understanding of the basic conditions necessary for the digital transformation of education, along with accurate cost estimates for these conditions. In Latin America and the Caribbean (LAC), the scarcity of reliable data is often an obstacle to evidence-based budgeting. Without clear parameters and defined investment costs, digital transformation policies are in danger of being poorly planned or stuck indefinitely in the design phase, lacking a clear path forward due to financial uncertainty.

To help overcome this challenge, the Inter-American Development Bank (IDB) and non-profit organization MegaEdu have partnered to create the [Digital Learning Cost Calculator](#). This free online tool helps policymakers estimate the cost of implementing digital learning in public schools. Specifically, the Calculator sets quality benchmarks, provides baseline data, and allows users to tailor inputs to local contexts, offering practical guidance to inform and accelerate effective planning.

By allowing policymakers to model scenarios and test cost assumptions, the calculator provides evidence-based projections that support strategic planning, budgeting and policy design. This is an initial analytical exercise designed to unlock and inform early-stage planning for digital learning initiatives.¹

The present document is the Technical Note accompanying the Digital Learning Cost Calculator. It describes the parameters, variables, assumptions, and costs estimation methods underpinning the Calculator, as well as the analytical framework and evidenced based data used to generate its results. The document

¹ The Calculator is not a price research tool and does not replace formal procurement processes. It provides only preliminary cost estimates intended to help policymakers understand the potential investment needs of the digital learning agenda.

is intended for policymakers and technical stakeholders involved in education planning and financing — including decision-makers, economic and education analysts, budget specialists, and officials within Ministries of Education and Finance — who need to estimate the costs of implementing digital learning strategies at national, regional, or local levels.

Beyond estimating costs, the document also explains the rationale behind the key parameters used in the Calculator, highlighting how these elements contribute to designing digital learning initiatives that can effectively support improvements in students' learning.

The Calculator's framework builds directly on the expanding body of research in digital education, notably the IDB's *AI and Education: Building the Future Through Digital Transformation* (Arias Ortiz et al., 2025). This research identifies five enabling dimensions necessary for digital transformation to achieve scale and equity, which form the backbone of the Calculator: **Connectivity, Devices, Teacher Training, Educational Platforms** and **Governance**. Together, they form the backbone of the calculator.

The Calculator innovates by considering this full range of components required for effective digital transformation, rather than focusing solely on a single item like devices. This holistic approach is essential because research consistently shows that meaningful and sustainable change in education depends on coordinated action across these multiple dimensions.

Taken together, these dimensions reinforce that digital transformation in education cannot be reduced to short-term interventions or isolated investments. Instead, it requires systemic coordination across sectors, alignment with pedagogical goals, and sustained financial planning. The Digital Learning Cost Calculator responds to this complexity by providing policymakers with a structured, evidence-based tool to organize data and simulate costs. Therefore, the tool is a practical instrument designed to assist policymakers in LAC in transforming the promise of digital education into sustainable policies that benefit the region's more than 124 million students.

Why is a Digital Learning Cost Calculator necessary?

In LAC, the scale of the digital learning challenge is immense. IDB's 26 borrowing member countries² are home to approximately 706,000 schools serving over 124 million students (Arias Ortiz et al., 2024). At the same time, the 2022 Programme for International Student Assessment (PISA) results reveal a severe learning crisis in the region, characterized by deep socioeconomic disparities and a widening gap between LAC countries and members of the Organisation for Economic Co-operation and Development (OECD) (PISA, 2022; Arias Ortiz et al., 2024). Urgent and targeted interventions are needed to support learning recovery and accelerate progress across education systems (Arias Ortiz et al., 2024).

Connectivity remains one of the most pressing barriers to digital learning. According to UNESCO (2023), only 44% of primary schools and 66% of secondary schools in LAC report having internet access, though these figures often overestimate the connectivity actually available for teaching and learning. In many cases, internet access is limited to administrative offices and does not reach classrooms. As a result, nearly 29 million children and adolescents remain completely disconnected, and in some contexts the situation is particularly acute—for example, almost 38% of schools in Brazil lack basic ICT equipment (CGI.br, 2024).

Connectivity levels also vary widely across countries. Nicaragua, Guatemala, and Honduras report some of the lowest levels of primary school connectivity (IDB CIMA, 2019), while Uruguay, El Salvador, and Costa Rica lead the region with near-universal school internet access at the same level—reflecting long-term public policies focused on digital inclusion in education (UNESCO, 2023a).

Public administrators often face significant challenges when planning digital learning strategies, including complex technical specifications, limited data, and few benchmarks to guide decision-making—especially in contexts with weak infrastructure or underserved populations. The Digital Learning Cost Calculator helps address this gap by enabling policymakers to estimate the cost of specific digital education interventions. For example, it can be used to estimate the investment required to connect all schools in a country to reliable internet or to

² Bahamas, Barbados, Belize, Bolivia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Suriname, Trinidad and Tobago and Uruguay. The remaining borrowing member countries include Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela.



Digital Learning Cost Calculator

calculate the cost of training teachers in digital competencies under different implementation scenarios. By providing structured parameters and transparent assumptions, the calculator supports more informed and strategic decisions about digital learning investments.

The absence of clear references and standardized benchmarks makes it difficult for policymakers to organize data and define investment priorities. Without this clarity, governments risk failing to deliver effective digital learning programs or even worse, it can exacerbate existing inequities in access to quality education and economic opportunity.

The Digital Learning Cost Calculator was created to address these gaps. It provides a structured framework that helps policymakers plan investments across five key dimensions of digital transformation: devices, connectivity, platforms, teacher training and governance. By organizing these elements into categories, the Calculator supports evidence-based decision-making and prevents isolated interventions, such as purchasing devices without ensuring teacher preparation or platform access.

The tool combines pre-filled educational data, price surveys and quality parameters derived from international and regional benchmarks. This structure helps answer three essential questions: what to purchase, how much is needed, and how much it will cost. Users can review and adjust the pre-filled fields to reflect their country context, producing tailored, transparent estimates for each policy scenario.

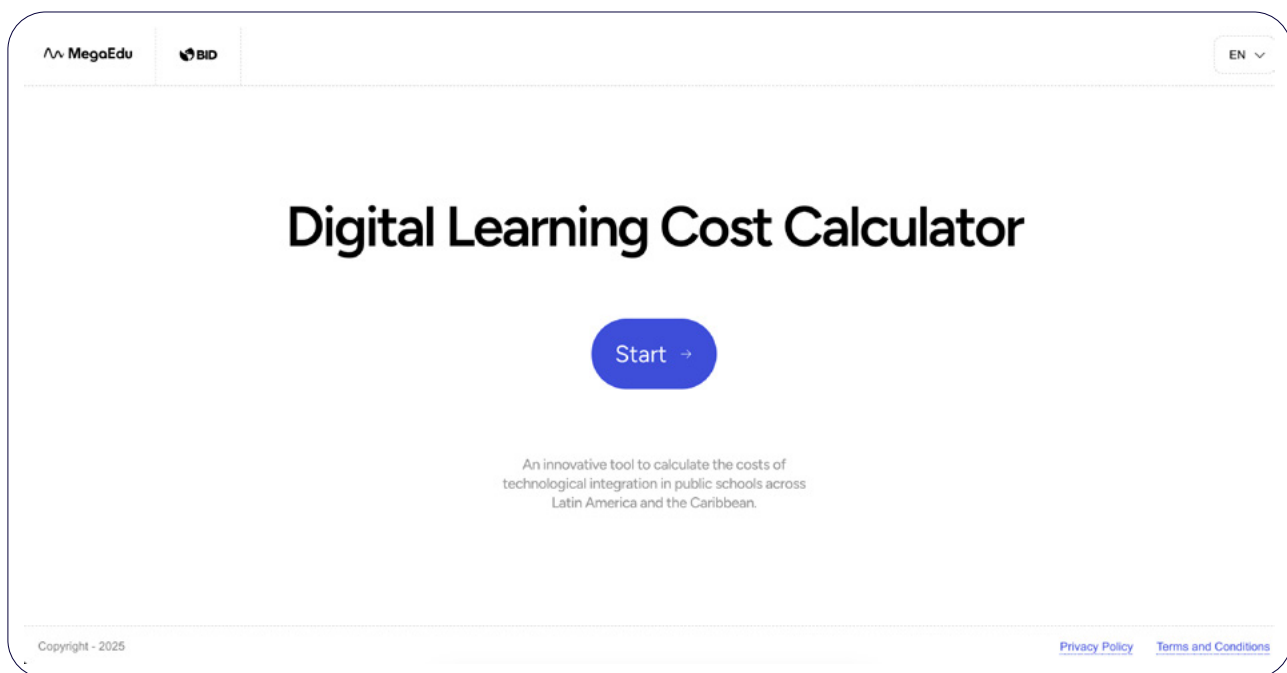
This integrated logic transforms raw data into actionable intelligence, enabling policymakers to explore critical investment and policy scenarios. For example, it can estimate the cost of achieving one-to-one device coverage in all primary schools, assess how overall budgets would change if school connectivity were upgraded from 10 Mbps to 50 Mbps, or determine the financial implications of extending teacher training to all educators at the intermediate level.

Ultimately, the value of the Digital Learning Cost Calculator lies in its ability to connect data, parameters, and assumptions within a coherent analytical framework that generates preliminary cost estimates. By translating these elements into structured cost models, the Calculator enables governments and develop-

ment partners to simulate alternative scenarios, evaluate trade-offs, identify investment gaps, and prioritize actions within real budget constraints. In this way, it functions as an early-stage planning tool and a first step toward building comprehensive and financially feasible digital education strategies.

How to use the Digital Learning Cost Calculator

The Digital Learning Cost Calculator is an intuitive free online tool designed to help policymakers estimate investment needs while making evidence-based decisions. It also works as a learning component, guiding users through each stage with clear explanations of the five enabling conditions. This built-in guidance helps them understand the context behind every choice and how each factor affects planning.



Source: <https://www.edudigitalcalculator.org>

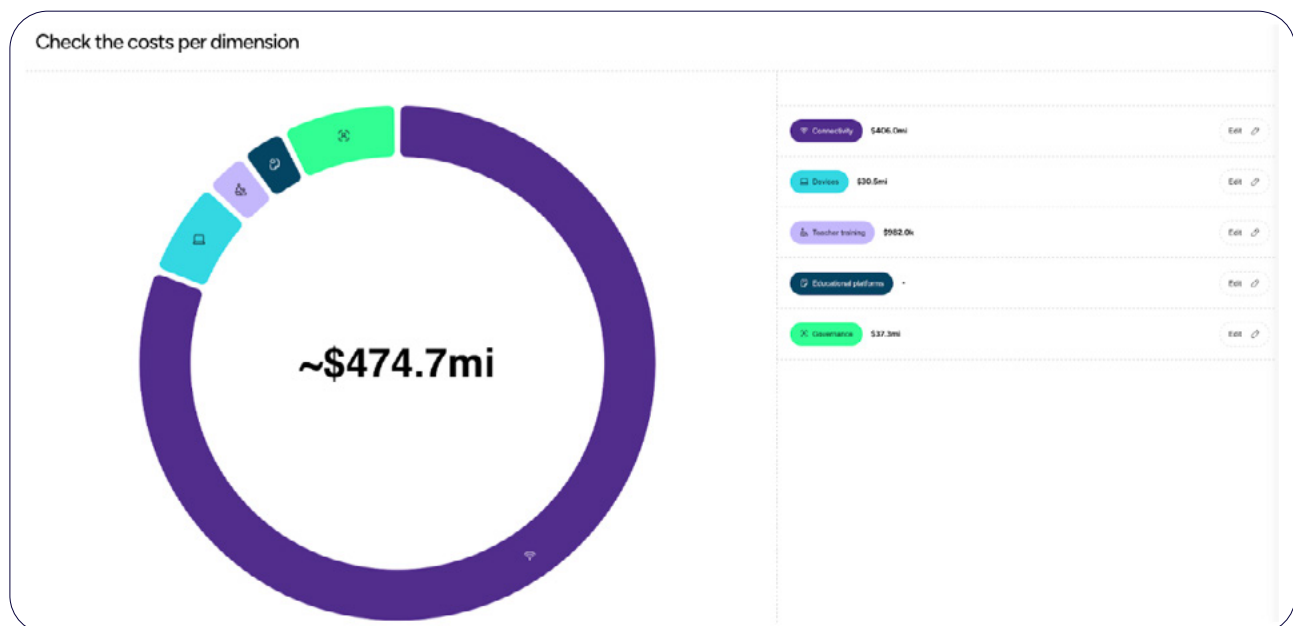
Each section of the calculator focuses on one enabling condition, one dimension. It presents the related costs and variables based on the country's context. Transparency is central to its design: all data sources and parameters are visible to ensure clarity in every estimate.

The Digital Learning Cost Calculator is designed for users with varying levels of

Digital Learning Cost Calculator

data maturity: those without national data can utilize the default information provided by the tool, while users possessing detailed data can adjust every variable to suit their specific context. This emphasis on flexibility and user-friendliness. Besides, when updating the values, the calculator will adjust automatically. For instance, as users change a value - such as updating the price of a laptop from \$500 to \$600 - the calculator instantly updates the total cost for that category. This makes it easier to see the impact of each adjustment in real time.

After a user works through the five dimensions, the final results page is presented. This page showcases different scenarios to help decision-makers assess the impact of prioritizing digital learning investments across different school groups. The final page provides a summary of the costs by dimension, while a downloadable PDF report offers a detailed breakdown of costs by individual item. Additionally, users have the option to download an Excel file, which allows running further customized analyses or simulations beyond the tool's standard output.



Source: <https://www.edudigitalcalculator.org>

In the following graphic there is a step-by-step summary detailing the process for working through the Calculator:

TABLE 1
How to use the calculator

Step	What should the user do?
1. Select your country	<p>Choose your country from the list.</p> <p>This step ensures that the calculator automatically loads specific educational data and prices</p>
2. Edit educational data	<p>Review and/or update the pre-filled information.</p> <p>The user can check the source and year of the prefilled data and, if available, they can edit the information.</p>
3. Review pre-filled data across dimensions	<p>Explore the five enabling conditions: Connectivity, Devices, Educational Platforms, Teacher Training and Governance.</p> <p>The user navigates a five-step process, one for each dimension. Each step provides a brief explanation and displays the items that require cost inputs. While a preliminary survey provides initial default values, users can edit these inputs if more accurate or context-specific cost information is available.</p>
4. Review the different scenarios	<p>Users can review the cost estimates generated under different implementation scenarios.</p> <p>The scenarios are: national (complete country implementation); rural schools (for closing the gap); secondary schools (for advancing digital skills focused on students trajectories); and teachers and school-only (for empowering teachers and enabling the schools).</p> <p>By examining these scenarios side by side, policymakers and technical teams can better understand potential trade-offs and identify the most feasible and cost-effective options for their context.</p>

5. Check the web report

Once all data is reviewed and customized, generate your final report.

Once the data has been refined, the calculator will generate a web report detailing the total cost for each dimension. The user is then able to select different scenarios or go back and edit the costs associated with any dimension.

6. Download the report

Download the PDF report and/or the Excel file

Once the best scenario is selected, the user is presented with the option to download the results as a PDF report and/or an Excel file.

The PDF report offers an item-by-item cost breakdown, providing the policymaker with a clear understanding of the financial arrangement. Downloading the PDF requires providing an email and organization name, and the report will open in a new window.

The Excel download contains all the underlying data in an editable format, allowing users to conduct further analyses or custom simulations.

Source: Authors

In practice, the report generated by the Calculator reflects a journey through the five dimensions of digital learning — Internet Connectivity, Devices, Educational Platforms, Teacher Training, and Governance. It is important to note that the figures generated by the Digital Learning Cost Calculator are estimates based on available data. They may not be fully accurate, nor are they meant to represent finalized budgets. Instead, they serve as a starting point — an initial exercise to guide strategic discussions, early-stage policy design and resource planning.

Dimensions of Digital Learning

Aligning technical parameters, educational data and cost methodologies presents a significant challenge. However, an organized model that can substantially simplify this process. This is precisely the objective of the Digital Learning Cost Calculator.

It departs from a framework of digital interventions in teaching and learning that takes into account five enabling conditions (hereafter called dimensions) for scalable impact (Arias Ortiz et al, 2025). Together, the five enablers ensure not just access but effective integration of technology in the learning process, creating the foundation for achieving policy goals.

First, internet **connectivity** is the foundation of meaningful digital education. In response to the worsening learning crisis and demands for new skills, many countries in LAC are increasingly committed to advancing the digital learning agenda in their educational system. In this sense, digital learning is considered a path not only to improving educational quality but also for ensuring that students develop the digital skills required for success in the 21st-century economy (IDB et al., 2024). This dimension goes beyond simply reporting overall school access rates. What truly matters is a stable, high-quality connection that reaches all rooms within the school. This focus ensures that classrooms themselves have connectivity that matches pedagogical demands. For example, while basic lesson planning requires minimal bandwidth, real-time video lessons depend on stable, high-speed infrastructure (Arias Ortiz et al., 2025).

Second, **devices** remain essential to ensure equity in education. The type of device selected to be used in a school must align with pedagogical needs: touchscreens may be essential for early writing skills, while older or poorly maintained hard-

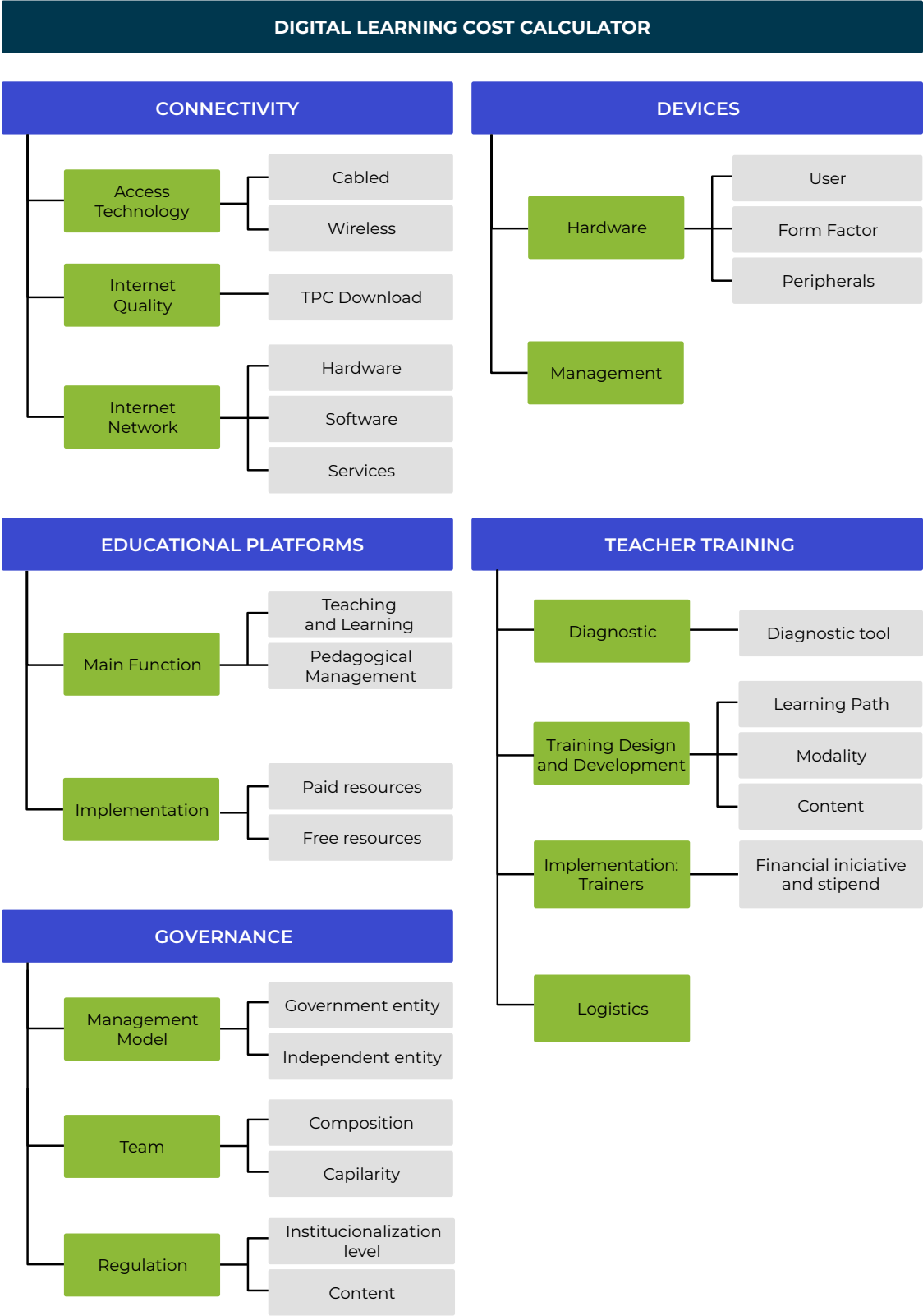
ware can undermine learning experiences. Uruguay's CEIBAL initiative illustrates this alignment, providing tablets to first and second graders, while offering laptops for students from third grade through secondary education (Ceibal, 2024). Beyond technical specifications, the quantity of devices is a core planning question. Educational systems have evolved from traditional computer labs (which present a fixed amount of devices per school) and one-to-one models. More recent examples showcase shared mobile solutions, such as device carts, which offer a strategic balance between accessibility and costs (Arias Ortiz et al., 2025).

Third, **teacher training** is indispensable. Research shows that technology's impact on student outcomes depends largely on how it is used in the classroom (United Nations, 2022). Teachers are not passive implementers but central actors in selecting, curating, and adapting digital tools to their students' needs. Policy-makers must therefore invest in defining, assessing, and supporting the development of teachers' digital skills while ensuring that professional development is continuous, context-sensitive, and inclusive. Without such investment, technology risks reinforcing rather than reducing educational inequalities (Arias Ortiz et al., 2025).

Fourth, **educational platforms** are, in general, the backbone of digital ecosystems. These tools expand opportunities for personalized learning and enable teachers to monitor student progress and enhance learning. (Arias Ortiz et al., 2025). However, their development requires rigorous quality assurance and strategic integration with curriculum goals. Platforms such as Learning Management Systems (LMS) allow schools to distribute content, assign tasks, evaluate performance, and even facilitate communication in hybrid and remote learning contexts. Beyond LMS, the ecosystem includes open educational resources, digital games, and online repositories—each of which can enrich learning when thoughtfully aligned with pedagogical strategies (Arias Ortiz et al., 2025).

Finally, **governance** (policy and coordination) provides the institutional architecture that makes digital transformation possible. Governance encompasses the legal frameworks, organizational structures, and resource allocation mechanisms that define roles, responsibilities, and long-term vision. Effective governance relies on institutional design, strong data systems, and sustainable financing.

Each dimension includes different subdimensions, parameters and variables. Here is an overview of the five dimensions and subdimensions:



Source: Authors

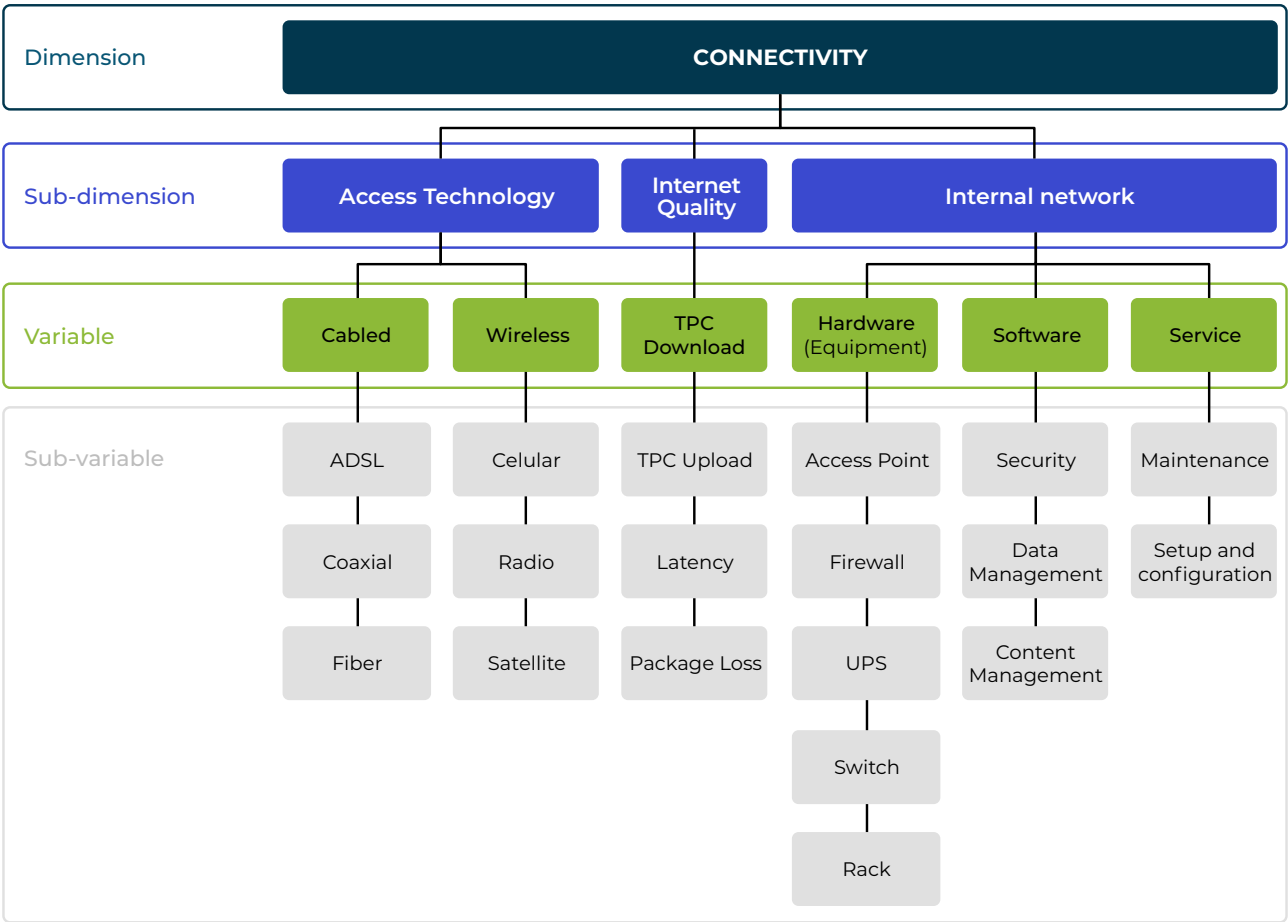


DIMENSION 1

Connectivity

The Internet dimension is essential for ensuring a school has meaningful connectivity to the digital world, enabling effective digital learning experiences. This dimension is not just about having some internet; it is about a robust and functional connection that supports teaching and learning.

This dimension addresses three key aspects: (i) Access Technology; (ii) Internet Bandwidth Quality; and (iii) Internal Internet Network (Wi-Fi). Each component will be detailed in the following sections.



Source: Authors

1. Access Technology

Ensuring internet access in schools begins with a fundamental question: how does the signal reach the school? The answer lies in access technologies—solutions that connect schools to the internet provider’s network, bridging the so-called “last mile.” This final segment is essential for delivering a stable and continuous connection, enabling schools to focus on service contracting rather than infrastructure deployment.

There is no one-size-fits-all approach. The choice of access technology, whether wired or wireless, directly impacts connection quality, cost and the feasibility of national connectivity strategies. Wired options range from outdated ADSL to high-performance fiber optic, which is now the gold standard for school environments. Coaxial cable, while more capable than ADSL, no longer meets the demands of digital education.

Wireless solutions, such as 4G/5G, radio and satellite, play a key role, especially in remote or underserved areas. Cellular and radio technologies offer quick deployment where infrastructure is lacking, while modern low-Earth orbit (LEO) satellites have become the only viable option for the most isolated schools.

Ultimately, the choice of access technology is technical, but it is also a strategic decision with direct implications for equity, inclusion, and the digital transformation of education. The following sections explore the strengths and limitations of each technology across different contexts in Latin America and the Caribbean.

1.1. Types of Access Technologies

When it comes to internet access, various technologies make connectivity possible. These can be broadly categorized into two main groups: **wired connections** and **wireless connections**. Each category encompasses technological solutions with distinct characteristics, capacities, and costs, all of which directly impact connection quality and the feasibility of implementation in educational settings.

Cabled/Wired Connections

Cabled/Wired technologies generally offer greater stability, speed, and lower la-

tency³. They are typically the most recommended option whenever available in a given region. Within this group, three key technologies stand out:

- **ADSL (Asymmetric Digital Subscriber Line):** This technology uses existing telephone line infrastructure. While historically a prevalent solution, ADSL is now largely considered insufficient for the demands of modern digital education. It typically offers very low speeds and exhibits high instability, making it unsuitable for the current bandwidth-intensive requirements of average schools (Infowester, n.d; CIEB, 2021)
- **Coaxial Cable:** Operating via cable TV networks, coaxial cable provides speeds superior to ADSL. However, it has limitations regarding availability and bandwidth sharing among users.
- **Fiber Optic:** This is the most advanced technology available, boasting extremely high speeds (which can exceed 1 Gbps), very low latency, and high reliability. Fiber is highly scalable and is considered the priority solution for school connectivity whenever it is available.

Wireless Connections

Wireless technologies are essential for expanding access in areas without cable infrastructure, such as rural, remote, and hard-to-reach locations. However, these technologies tend to have more limitations in terms of stability, latency, and cost per megabit when compared to wired connections. Key solutions include:

Cellular (4G/5G): This utilizes mobile networks and can be rapidly deployed, either via SIM-card routers, modems, or directly on mobile devices. Nevertheless, the high cost per gigabyte, data caps, and signal variation limit its use as a primary connectivity solution for schools.

- **Radio:** Radio technology enables signal transmission through antennas without the need for physical cables to the school. It's an interesting option in isolated areas, but it is susceptible to interference from weather, terrain, and physical obstacles, which can compromise connection quality.
- **Satellite:** Satellite connectivity is divided into two types:

³ **Latency** is the time it takes for data to travel from its source to its destination across a network. Lower latency reduces delays in transmitting information, which is especially important for real-time applications such as video conferencing, online learning, and interactive digital tools (ITU, 2020).

- ◇ **GEO (Geostationary Earth Orbit) satellites** offer broad coverage but come with very high latency, limiting synchronous activities like online classes.
- ◇ **LEO (Low Earth Orbit) satellites**, a more recent technology, provide higher speeds and significantly lower latency, making them a more viable alternative for schools in extremely isolated regions.

Each of these technologies has its advantages and challenges. Their adoption in an educational context should be based on technical, operational, and economic criteria, taking into account the school's location, the availability of infrastructure, and the pedagogical demands associated with the use of digital technologies.

The table that follows will provide a comparative summary of the main internet access technologies, outlining their technical characteristics, advantages, disadvantages, and recommended uses in a school setting.

TABLE 2
Different types of technologies

Technology	Average Download Speed	Average Latency	Main Advantages	Main Disadvantages	Suitability for Schools
ADSL	1–24 Mbps (e.g., Anatel, 2023)	30–100 ms (e.g., NIC.br, 2022)	Low cost, leverages existing telephone networks, widespread urban availability	Low speed, very limited upload, unstable connection, outdated for current digital demands	Usually, not recommended
Coaxial Cable	25–300+ Mbps (e.g., Minha Conexão, 2024)	10–40 ms (e.g., NovaNews, 2024)	Faster and more stable than ADSL, easy deployment where cable TV infrastructure exists	Limited to cable TV network areas, shared bandwidth reduces performance during peak usage	Usually, not recommended
Fixed Wireless (Radio)	1–50 Mbps (e.g., Telesystem, n.d.)	20–100+ ms	Reach in remote areas, rapid deployment, no cabling required	May be unstable due to weather or interference, high latency, variable speed	Recommended for schools in specific cases
Mobile (4G)	15–50 Mbps (Brazil average ~29 Mbps) (e.g., Opensignal, 2024)	30–60 ms (e.g., Minha Conexão, 2023)	Mobility, broad coverage, simple installation	Data caps, high cost per GB, signal instability in remote or congested areas	Recommended for schools in specific cases

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Fiber Optic	100 Mbps – 10 Gbps (e.g., Minha Conexão, 2025)	<10–20 ms (e.g., Transmitter, 2021)	Very high speed, low latency, stable connection, scalable	High initial deployment cost, limited coverage in urban and peri-urban areas	Best option
Satellite (GEO)	10–100 Mbps (e.g., Teletime, 2021)	500–700 ms (e.g., Teletime, 2021)	Global coverage	High latency, not suitable for synchronous activities (e.g., online classes), data caps, high cost, weather-dependent	Recommended where no other alternatives are feasible
Satellite (LEO)	50–250 Mbps (e.g., Starlink, n.d.)	20–50 ms (e.g., Starlink, n.d.)	Broad coverage, low latency (vs. GEO), stable speeds, unlimited data plans	High upfront cost, ongoing coverage expansion, monthly cost higher than wired networks	Recommended in remote areas when fiber is not available

Source: Authors

1.2 Recommended Access Technology Parameters for Schools

Fiber-optic is widely recognized as the optimal connectivity technology for schools because it provides high speeds, low latency, and strong stability—essential for environments with multiple users and intensive use of digital platforms, video conferencing, and cloud-based resources. It is also highly scalable, enabling networks to accommodate future technological demands without replacing infrastructure. As the Fiber Broadband Association (2024) notes, fiber “remains the only communications infrastructure that can support not only existing applications but also those yet to come.” For this reason, whenever technically and economically feasible, fiber-optic should be the preferred solution.

However, many rural and remote schools cannot access fiber infrastructure and must rely on alternative technologies such as satellite, microwave links, or mobile networks. In these contexts, partnerships with public and private telecommunications providers are essential to ensure equitable connectivity across diverse geographies (Arias Ortiz et al., 2025). Satellite internet, in particular, often becomes the only viable option due to its wide coverage. While traditional geostationary satellites (GEO) faced limitations such as high latency and data caps, newer generations offer improved speeds, lower latency, and more competitive plans (Inuknet, 2025).

In practice, the choice between fiber and satellite depends on local infrastructure availability. When contracting services, local providers should be consulted to confirm whether fiber infrastructure exists near each school. For the costing model, however, general estimates are used to assess the national scale of the connectivity challenge, indicating how many schools may have fiber access and how many may require satellite connectivity.

We categorize schools into three groups:

- **Group 1 – Schools near existing fiber:** Schools located in urban or peri-urban areas with fiber coverage already in place or imminent. For these schools, only the internet service subscription is needed, as the physical infrastructure is available or soon will be. The subscriptions will be calculated considering a fiber service.
- **Group 2 – Schools within reach of fiber via investment:** These schools lack current fiber access but are located in areas with wider demand (e.g., neighboring communities). Here, deploying a “last-mile” fiber connection to the school may be viable with government subsidies or credit support. Large-scale backbone investments are excluded, as they fall beyond the scope of education policy. Here the costs are calculated in two parts. First, an initial investment for fiber deployment followed by the subscription of the fiber service.⁴
- **Group 3 – Remote schools:** These are typically in isolated regions—deep rural, mountainous, or surrounded by rivers—where fiber installation is impractical, even in the medium term. Satellite connectivity will be necessary. Here we are considering satellite installation and service as the cost.

To estimate how many schools fall into each group, we use data from the International Telecommunication Union (ITU, 2023), which shows population distribution by distance from fiber infrastructure. Since exact school locations relative to fiber lines are unavailable, we assume that schools are proportionally distributed in line with population densities. In other words: where more people live, more schools exist. This allows us to apply population percentages directly to the number of schools to determine their likely connectivity group.⁵

⁴ During the implementation phase, those costs do have to consider appropriate timing: the cost of service comes after the infrastructure deployment. For simplification, we are assuming all of the cost for t0. More about the cost methodology on the Cost Estimates section.

⁵ We calibrated these benchmarks using recent public policy experiences in Brazil (e.g., fiber rollout tenders) and the margin of error is lower than 15%.

Assumptions:

- **Group 1:** Population living within 25 km of fiber.
- **Group 2:** Between 25 and 50 km of fiber.
- **Group 3:** More than 50 km away from fiber.

For example, in Colombia:

- **69%** of the population lives within 25 km of fiber → we assume 69% of schools are Group 1.
- **20%** of the population lives between 25–50 km from fiber → Group 2.
- **11%** of the population lives beyond 50 km from fiber → Group 3.

This methodology enables national-level estimates of school connectivity needs even in the absence of school-specific infrastructure data. If more precise data is available, they can replace these assumptions for greater accuracy.

2. Internet Quality

In recent decades, the rapid advancement of technology has created new dynamics in social relations and production processes worldwide, requiring the re-interpretation of concepts, the development of new skills, the strengthening of citizenship, and the adoption of practices that reduce inequalities.

In this context, access to broadband internet is essential for a knowledge-based economy and for emerging business models that depend on data access, information sharing, and virtual collaboration. Over the past decade, numerous studies have shown that increased broadband penetration is linked to economic growth. Research by the Inter-American Development Bank (IDB, 2012) and the Institute for Applied Economic Research (IPEA, 2017) finds that a 10% increase in broadband penetration correlates with GDP growth between 0.77% and 3.19%. More recent evidence highlights additional benefits, including reductions in CO₂ emissions (World Economic Forum, 2019), improved educational opportunities for women and girls (Intel Corporation, 2012), and productivity gains in sectors such as agriculture, transport, and energy distribution (GSMA, 2020).

In education, internet access should be considered a fundamental tool. Lack of connectivity and low digital literacy are indicators of social inequality, as they lim-

it access to education, employment, public services, and information (IDB et al., 2024). Without connectivity and digital skills, individuals are excluded from economic and social opportunities, reinforcing cycles of poverty and marginalization and widening social disparities.

Internet connectivity has therefore become essential in public education, enabling teachers and students to access learning resources such as video lessons, educational games, adaptive platforms, and real-time collaboration tools. Technology also allows students to learn at their own pace across different spaces and times, making education more responsive to an increasingly digital world.

However, school connectivity must always be aligned with educational objectives and expected technology use. Adequate connectivity depends on who will use it, where it will be used, and how it will be used. Schools require reliable, high-speed internet that supports teachers' planning and classroom practice, administrative management, and students' daily learning activities, with connectivity available throughout the school (CGI.br, 2024).

Achieving this requires basic infrastructure, including internal networks that ensure high-quality Wi-Fi coverage, proper network management and security, and sufficient bandwidth to support multiple simultaneous users.

The key metrics used to evaluate network quality are TCP Download, TCP Upload, Latency, Jitter, and Packet Loss. TCP Download measures the efficiency of data transfer from server to client, directly impacting user experience in tasks like web browsing, video streaming, and file downloads, while TCP Upload measures the reverse flow — from client to server — and is essential for activities such as uploading files, video calls, and sending email attachments. Latency refers to the Round Trip Time (RTT) a data packet takes to travel from source to destination and back: low latency signals a fast, efficient network ideal for gaming and video conferencing, whereas high latency introduces noticeable delays that degrade the experience in interactive applications. Jitter measures the variability in packet arrival times, with high jitter causing irregular transmission that disrupts real-time applications like VoIP and video conferencing. Finally, Packet Loss indicates the percentage of packets that never reach their destination, typically caused by network congestion, hardware failures, interference, or misconfigurations.

Internet contracts for schools are generally based on the Connection Speed metric (TCP Download). While it is not the sole metric that defines connection quality, it is the standard for agreements between the school (the client) and the internet service provider (the ISP).

All metrics will fluctuate based on factors such as access technology, the number of users sharing the network, and the quality of the internal infrastructure (Wi-Fi).

There are several approaches to defining internet bandwidth requirements for schools. One may consider a minimum package for the entire school, a minimum per classroom, or even a minimum per user. Since connection quality is directly affected by the number of devices (users) connected simultaneously and the expected pedagogical use, it is recommended to define minimum internet parameters based on speed per user.

In recent years, many countries have adopted public policies establishing minimum internet speed standards to support effective digital pedagogy in schools. In the United States, Education Superhighway recommends **at least 1 Mbps per student** to ensure stable digital learning (Education Superhighway, 2024). Estonia, a global leader in educational digitization, has guaranteed universal school connectivity since 2001 through the Tiger Leap Program and since 2015 requires **1 Gbps per school with Wi-Fi in every classroom** (Education Estonia, 2024).

In the European Union, the European Commission recommends **30–100 Mbps per classroom**, depending on digital maturity and pedagogical use, as part of the “highly equipped and connected classroom” standard (European Commission, 2019). Similarly, Spain’s **Escuelas Conectadas** program established **100 Mbps per school** under the Digital Culture Plan in the School (Red.es, 2024), while Ireland’s national broadband program connected all post-primary schools with at least **100 Mbps** (European Commission, 2019).

These benchmarks reflect the growing recognition of connectivity as a prerequisite for educational equity. In Brazil, the **National Strategy for Connected Schools (ENEC)** recommends **1 Mbps per student**, a standard also supported by the **Inter-institutional Group for Connectivity in Education (GICE, 2021)** to enable activities such as video use, educational games, and collaborative platforms.

Even though schools also serve other users—such as teachers, administrative staff, and, in some cases, members of the broader school community—it is understood that not all students are online 100% of the time. Students engage in various offline activities as part of their daily routines. Therefore, calculating internet speed based on the number of enrolled students is generally sufficient to meet the needs of the entire school community. This approach not only supports students but also simplifies determining the ideal internet speed needed for day-to-day operations.

Beyond considering the number of students (i.e., network users), determining the ideal internet speed also depends on the type of pedagogical use intended. Common educational activities that impact bandwidth include file downloads and uploads, online research, email communication, educational games, collaborative learning platforms, social media for educational purposes, video lessons, video conferencing, and VoIP calls, among others.

2.1. What Is the Recommended Connectivity Parameter?

A study by Brazil's Network Information Center (Núcleo de Informação e Coordenação do Brasil – NIC.br) analyzed the minimum speed and other quality metrics required for different educational activities. Video-based activities, for instance, demand higher download speeds, faster response times (i.e., lower latency), and greater stability (reduced latency and jitter). The table below outlines the requirements for each type of use:

TABLE 3
Internet Quality Metrics

Quality Metrics	Audio Activities	General Use	Download	Gaming	Video
TCP Download	0.27 Mbps	1 Mbps	5 Mbps	3.75 Mbps	3.44 – 8.25 Mbps
Latency	128 ms	300 ms	80 ms	90 ms	60 ms
Packet Loss	up to 2%	up to 2%	up to 2%	up to 1%	up to 0.5%

Source: Adapted from Bettega et al. (2020)

Given these parameters, GICE (2022) developed a formula based on two factors: the number of students using the internet simultaneously and the type of activity they engage in. Since video streaming is one of the most bandwidth-intensive activities, it served as the baseline for calculations. The logic is simple: the more students online at once—and the more demanding their activities (e.g., videos)—the higher the required internet speed.

Additionally, internet providers rarely deliver 100% of advertised speeds. Thus, the formula incorporates a safety margin to ensure stable performance despite fluctuations. If a school's connection can support multiple students streaming videos concurrently, it will also handle lighter tasks like accessing educational platforms, downloading files, or video calls.

These scenarios demonstrate realistic possibilities for meaningful internet use in teaching and learning processes at schools. For any of these scenarios to function effectively, ensuring good connection quality is paramount. **The minimum recommendation is 1 Mbps per student**, which helps guarantee uninterrupted internet access and a positive learning experience. Connection quality can either significantly enable or severely hinder students' learning experiences.

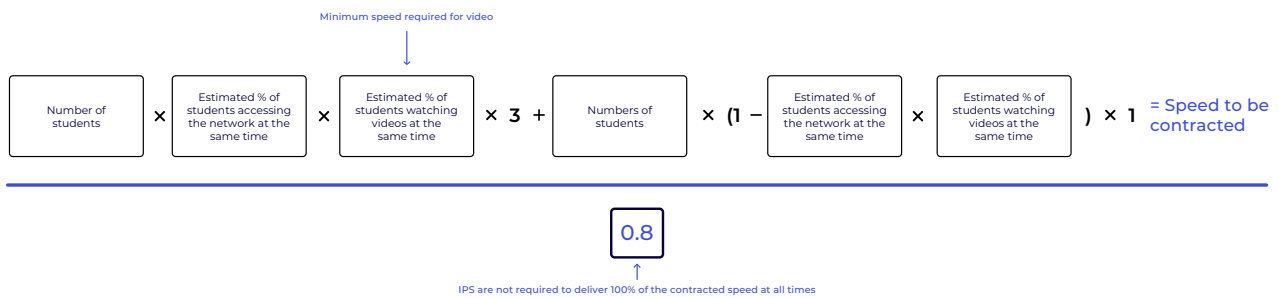
The recommended 1 Mbps per student parameter represents a practical adaptation of the connectivity formula to real-world school usage patterns. It acknowledges that, at any given time, some students will be engaged in internet-based activities while others are working offline. Among those using the internet, activities will vary from basic Browse to more demanding tasks like video streaming.

Key Assumptions of the Formula

The formula hinges on two premises:

- **Simultaneous users:** The number of students connected at peak times.
- **Pedagogical activities:** Video streaming was selected as the benchmark due to its high bandwidth demands (TCP Download). Meeting this threshold ensures all other activities (e.g., research, emails) are adequately supported.

Based on this formula, we can illustrate what **1 Mbps per student** can enable. For a school with **500 students**, consider these three practical usage scenarios, offering public administrators a quick, actionable reference for internet speed planning:



Source: Adapted from Gice (2022)

- **All students connected simultaneously for basic activities**
Example: All students use the internet for lightweight tasks (email, Google searches, reading articles).
- **Half the class connected, with one-third streaming videos**
Example: 250 out of 500 morning students are online; 80 watch educational videos (YouTube, Khan Academy).
- **One-quarter of the class streaming videos simultaneously**
Example: 125 students engage in synchronized video lessons.

It is important to note that the formula offers **flexibility in determining the contracted speed**: if a school desires a higher percentage of concurrent users or anticipates more intensive usage, adjusting the variables within the formula will change the recommended speed accordingly. However, the **1 Mbps per student parameter serves as the minimum recommendation** necessary to support the primary pedagogical activities in daily school operations.

3. Internal Network (Wi-Fi)

To achieve a connection that can indeed transform the school⁶ two fundamental components must be met: adequate connection speed and an efficient Wi-Fi infrastructure. The first one was explored in the previous section, however, simply hiring an internet service with the ideal speed is not enough to ensure pedagogical use of technology. The school also needs to distribute this connection across







⁶ It is worth checking the concept of meaningful connectivity that has been developed by the Alliance for Affordable Internet (A4AI), a global coalition working to ensure universal access to quality internet, as a way to differentiate the levels of internet access.

different spaces since multiple students in various classrooms use the same network. Thus, it is essential to build a robust Wi-Fi network.

A well-designed Wi-Fi network ensures stable and continuous internet access across all educational spaces in the school, including classrooms, libraries, courtyards, laboratories, and administrative areas. This eliminates the limitation of internet use to specific environments, such as traditional computer labs, and enables students and teachers to use digital resources in real-time, fully integrated into daily teaching practices. Therefore, implementing Wi-Fi connectivity in public schools is a priority, given its importance in supporting the effective use of technology in pedagogical activities.

3.1. Hardware components

A complete wired Wi-Fi network solution typically consists of a security firewall, distribution switches, and wired access points, and also ensure electrical stability and a layer of maintenance and network management services. The following section will explain each of the hardware components that make up a Wi-Fi solution, followed by the key associated services.

Electrical Stability	Internal Network			Services	
	Routing and Security	Distribution	Signal Coverage		
					
Nobreak	Router / Firewall	Switch	Access point	Maintenance	Management
Protects equipment from electrical fluctuations and acts as a battery in case of a power outage.	Connects the internal network to the internet and provides security functions such as content filtering, data protection, etc.	Distributes wired access to all devices on the network	Distributes the wireless signal (Wi-Fi) throughout the school environment.	Support and maintenance service as needed	Dashboards and centralized remote access to schools and equipment

3.1.1 Access Point (AP)

An Access Point (AP) is a networking device that allows wireless devices, such as smartphones, laptops, and tablets, to connect to a Local Area Network (LAN) via Wi-Fi. It acts as a bridge between wireless devices and the wired network, expanding signal coverage and enhancing connectivity within the environment. It is an effective solution for improving Wi-Fi coverage and providing stable, reliable access, especially in settings with high connectivity demands.

Key functions of an Access Point:

1. Extends Wi-Fi signal range, making it ideal for large areas or spaces with obstacles where the primary router's signal may not reach;
2. Allows multiple devices to connect simultaneously, making it ideal for schools, offices, stadiums, events, or any environment with high user density;
3. Supports the creation of separate Wi-Fi networks, such as one for visitors and another for internal use.

How an AP works:

The AP connects to a router, switch, or server through an Ethernet cable, transmitting the Wi-Fi signal and enabling wireless devices to connect to the network. Once connected, devices can access the internet and other local network resources such as printers or file servers.

3.1.2 Switch

A switch is a networking device that connects multiple devices within a Local Area Network (LAN) and enables efficient communication between them. Acting as an intelligent hub, it forwards data directly to the intended device rather than broadcasting it to all devices on the network. This improves network speed, organization, and security. Switches are essential for Wi-Fi networks, ensuring fast, efficient, and secure connections between

devices. They are widely used in settings that require reliable connectivity, such as offices and schools.

Key Functions of a Switch:

1. Directs data intelligently, optimizing network communication.
2. Segments the network to reduce congestion.
3. Minimizes data collisions and enhances transmission speed.

How it works:

When a device (e.g., a computer, printer, or server) sends data, the switch receives the data through one of its ports, analyzes it, and checks the recipient's MAC address (a unique identifier for each device). The switch then forwards the data only to the port associated with the destination device rather than broadcasting it to the entire network. This allows multiple devices to simultaneously send and receive data without interference.

3.1.3 Surge Protection Device (SPD)

An SPD (Surge Protection Device) safeguards a school's electrical network, protecting critical electronic equipment—such as networking hardware—from voltage spikes and surges that could cause damage.

Key functions of an SPD:

1. Diverts electrical surges (voltage spikes) to the grounding system, enhancing electrical safety;
2. Protects connected electronics, preventing costly damage from power fluctuations.

How an SPD works:

SPDs are typically installed at the main electrical distribution board, near the main circuit breaker, to protect the entire school's electrical infrastructure

from surges originating from the utility grid. In larger networks, additional SPDs can be installed at strategic points. The SPD functions as a barrier, protecting the local electrical network from voltage spikes—whether caused by lightning strikes, sudden load changes, or grid faults—by redirecting excess energy to the grounding system. This process happens in fractions of a second, ensuring the safety of connected equipment.

3.1.4 Uninterruptible Power Supply (UPS or Nobreak)

A UPS is a device that provides temporary electrical power to electronic equipment during outages or power fluctuations. It acts as an “emergency battery” that automatically activates during power failures, ensuring that connected devices remain operational for a limited time.

Key functions of a UPS:

- Supplies temporary power to connected devices during outages.
- Regulates voltage fluctuations, protecting connected equipment from minor surges.
- Advanced models deliver continuous, stabilized power, fully isolating devices from the main electrical grid to prevent performance issues caused by voltage variations.

How it works:

The UPS connects to the main power outlet, while electronic devices connect directly to the UPS. Under normal conditions, it acts as a voltage filter, protecting equipment from minor fluctuations. Its main function activates during power outages when it switches to its internal batteries to continue supplying power to the devices until the grid power is restored or the battery runs out.

For the school’s Wi-Fi solution, core network devices (switches, access points, and firewalls) should be connected to the UPS. This ensures that the internet remains operational during power instability, preventing data

loss and protecting the equipment from damage.

3.1.5 Firewall

A hardware firewall is a dedicated device that protects a network from unauthorized access, cyberattacks, and unwanted traffic. Acting as a barrier between the internal (private) network and external networks such as the internet, it monitors, filters, and controls data traffic based on predefined security rules.

Key functions of a firewall:

1. Blocks intrusion attempts and exploitation of network vulnerabilities.
2. Ensures that only authorized users and devices can access certain network resources.
3. Restricts access to undesirable websites or services, such as social media, adult content, games, or malicious sites.
4. Monitors network traffic to detect suspicious activities, including abnormal traffic volumes or unauthorized access attempts.
5. Advanced models detect and mitigate threats like malware, ransomware, or DDoS attacks.

How it works:

All inbound and outbound network traffic passes through the firewall. It inspects data packets (units of transmitted information) to determine their origin, destination, data type, and other details. Based on configured security policies, the firewall decides whether to allow, block, or redirect traffic. It can filter based on:

- **IP Address:** Allows or blocks traffic from specific addresses.
- **Network Ports:** Manages access to specific services (e.g., HTTP, HTTPS, FTP).
- **Protocols:** Analyzes communication types, such as TCP, UDP, or ICMP.
- **Content:** Some advanced firewalls perform deep packet inspection to

detect harmful content.

3.1.6 Rack

A rack is a metal framework designed to organize, house, and protect IT and telecommunications equipment such as servers, switches, routers, firewalls, storage devices, and UPS units. It helps maintain organization, simplifies maintenance, and optimizes the use of physical space—especially in data centers, offices, or institutional environments.

Key functions of a rack

1. Organizes equipment in one location, avoiding clutter and cable mess;
2. Protects devices from dust, moisture, and physical damage while facilitating proper ventilation to prevent overheating;
3. Provides quick access for maintenance, repairs, and upgrades;
4. Maximizes physical space efficiency, especially in environments with multiple devices.

Additional features

Racks follow international sizing standards measured in “U” (rack units), where 1U equals 1.75 inches (approximately 4.45 cm) in height. This standardization ensures compatibility between equipment and racks. For schools, a rack between 6U and 8U is typically sufficient.

3.2. Quality parameters for the Wi-Fi network

The vision of success for a Wi-Fi network implemented in a school is one where entire classrooms can simultaneously connect to the network and securely access educational content from any learning space within the school. This ensures that the full potential of the contracted internet link is realized.

The following recommendations are grounded in the main international standards for Wi-Fi network quality such as the guidelines from the Federal Commu-

nications Commission (FCC) in the United States, the European Commission.

Additionally, the parameters recommended in this section are based on the study *Wi-Fi Connectivity for Brazilian Public Schools*, published by MegaEdu in partnership with the Inter-American Development Bank (IDB & MegaEdu, 2024). This study consolidates and analyzes best practices for implementing Wi-Fi solutions in public schools. It involved interviews with over 70 experts from government agencies, the private sector, NGOs, and international organizations, in addition to an extensive review of literature and technical documents.

Wi-Fi signal strength is typically measured in dBm, a unit that indicates signal power. These values are always negative, ranging from -100 to 0. The closer the value is to 0, the stronger the signal. Conversely, values approaching -100 represent weaker signals, which can cause slow connections or outages. Technical papers and industry best practice guides indicate that a Wi-Fi signal strength of -70 dBm is the minimum threshold to enable “general use” activities, such as browsing the web, reading news, and sending emails (MetaGeek, 2021).

Ideally, an on-site survey should be conducted to ensure high-quality Wi-Fi signal coverage in all school environments, with in-person validation after installation. However, remote logical validation can be performed prior to installation using heatmap software that works with the school’s floor plan.

For this calculator and for general planning, (when survey is not feasible), it is recommended to consider one Access Point (AP) for every two school environments, positioning them strategically to optimize Wi-Fi signal distribution across all spaces. Although this ratio may not always result in the exact number of access points needed for a specific school, it is a widely recognized proxy in the industry. It was repeatedly cited during the interviews conducted for this study as a reliable rule of thumb when remote validation is not possible. For the other wi-fi devices (router/firewall, switch, UPS/SPD) the recommendation is one per school.

3.3. Wi-Fi Management and Security

In a context where connecting public schools to the internet is both urgent and essential, the role of network security and Wi-Fi management software becomes central. Beyond maintaining stable connections, these tools are key to ensuring

that the digital experience within schools is efficient, secure, and accessible. By enabling continuous monitoring of connectivity and facilitating technical adjustments, these systems make network usage more reliable and manageable. More importantly, they go beyond technical functions: by protecting user data and simplifying control over the connected environment, they help students and educators navigate safely—combining digital inclusion with privacy protection.

When deploying Wi-Fi networks in public schools, it is crucial to adopt software that integrates robust digital security features and data protection mechanisms. According to technical guidelines by UNESCO (2020), educational platforms and systems must ensure the confidentiality, integrity, and availability of information—particularly regarding the handling of personal data from children and adolescents.

The core functions of network management software include:

- Monitoring information about connected devices, bandwidth usage, and overall network health.
- Supporting the rapid identification of bottlenecks or technical issues.
- Enabling bandwidth limitations per device or application to prevent any user or app from consuming disproportionate resources.
- Simplifying adjustments such as password changes, creation of new networks (SSIDs), or security configuration updates—directly through the software without requiring physical access to the hardware.
- Providing network usage reports to help identify patterns, plan for upgrades, and anticipate future problems.

In terms of Wi-Fi security, the software plays a critical role in protecting the network. Digital security involves safeguarding systems, networks, and programs against both internal and external threats. In the school environment, a digital security solution should, at a minimum, include the following functionalities:

- Content filtering to block access to specific websites and applications.
- Network monitoring and analysis to verify accessed content and ensure safety.
- Protection against both external and internal risks, as well as preservation of users' personal data.

- Regular updates to software and equipment firmware, ensuring optimal performance with the latest security patches.

The use of personal data is common in education for tracking student performance, evaluating teacher effectiveness, and informing educational policies. However, handling of such data must be approached with caution and responsibility, especially when it involves children and adolescents. Globally, personal data protection has been regulated in various countries to safeguard privacy rights and ensure control over individual information.

In the deployment of school Wi-Fi networks, prioritizing security is essential to protect user data and enable safe browsing. Content filtering decisions should involve a multidisciplinary team comprising educators, administrators, and technical experts. Furthermore, promoting digital citizenship for various users is indispensable. This involves raising awareness among students and teachers about the safe and responsible use of technology, fostering best practices, and encouraging critical thinking in online environments.

Finally, school systems must provide appropriate technological infrastructure, including management systems capable of applying content filters, monitoring safe usage, and protecting user data. These measures are fundamental to creating a safe educational environment that supports learning while aligning with each school's pedagogical mission.

3.4. Services and Maintenance

When it comes to technology, having reliable support and maintenance services is crucial to ensure that the technological infrastructure continues operating smoothly over time. In this context, it is essential to establish a maintenance contract that covers both preventive and corrective actions, guaranteeing that the Wi-Fi network consistently serves students and educators without disruptions. Additionally, this support must be structured with clearly defined response times and criteria, ensuring that schools are not left unsupported during critical periods.

To optimize the cost-effectiveness of the Service Level Agreement (SLA), it is considered good practice to define response times based on two key variables: the

urgency of the issue and the school's geographic location (Cisco Systems, 2005). For example, schools located near major urban centers can benefit from shorter response times due to easier access for service technicians. Conversely, schools in remote areas, where access is more challenging, may require longer response times for issue resolution, which contributes to more efficient planning and balanced costs.

In addition to maintenance and technical support, the recurring cost of internet service must also be covered. In the Calculator, this is estimated using reference prices for the two most common connectivity options available to schools: fiber-optic and satellite connections. For fiber connectivity, the model uses the average monthly cost of a 200 Mbps fiber internet service, which represents a typical capacity required to support multiple simultaneous users in a school environment.

For schools that cannot access fiber infrastructure — particularly in rural or remote areas — the model considers the average monthly cost of a satellite internet connection, inclusive of installation fees. When the reference price includes an installation cost, this cost is amortized over a 48-month period (corresponding to a four-year contract) and incorporated into the monthly service fee. This approach ensures that the costing model reflects the real operational expenses associated with maintaining school connectivity over time.

This differentiated approach not only addresses the urgency of local demands but also aligns expectations more realistically, balancing immediate needs with logistical and budgetary constraints.

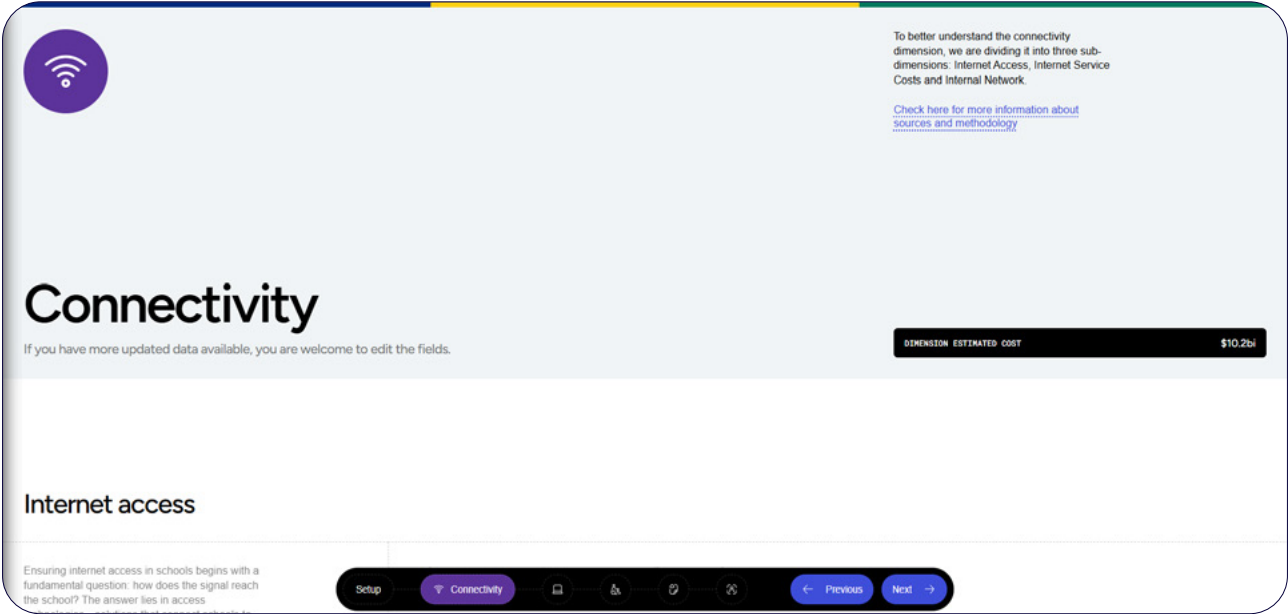
3.5. Summary Table

Therefore, for the connectivity dimension the calculator determined the costs for these items;

TABLE 4
Overview of the Connectivity Dimension

Subvariable	Parameter	Quantity
Fiber Expansion	25 km of fiber expansion per school	% of schools that need fiber expansion
Satellite Service	all remote schools	% of remote schools
Fiber Link	all schools that are not remote with fiber 1 mbps per students	% of schools that are not remote number of students
Access Point (AP)	1 AP/classroom	Number of classroom
Firewall	1 per school	Number of schools
UPS (Nobreak)	1 per school	Number of schools
Switch	1 per school	Number of schools
Rack (6U/8U)	1 per school	Number of schools

How does this dimension look in the Calculator?



Source: <https://www.edudigitalcalculator.org>

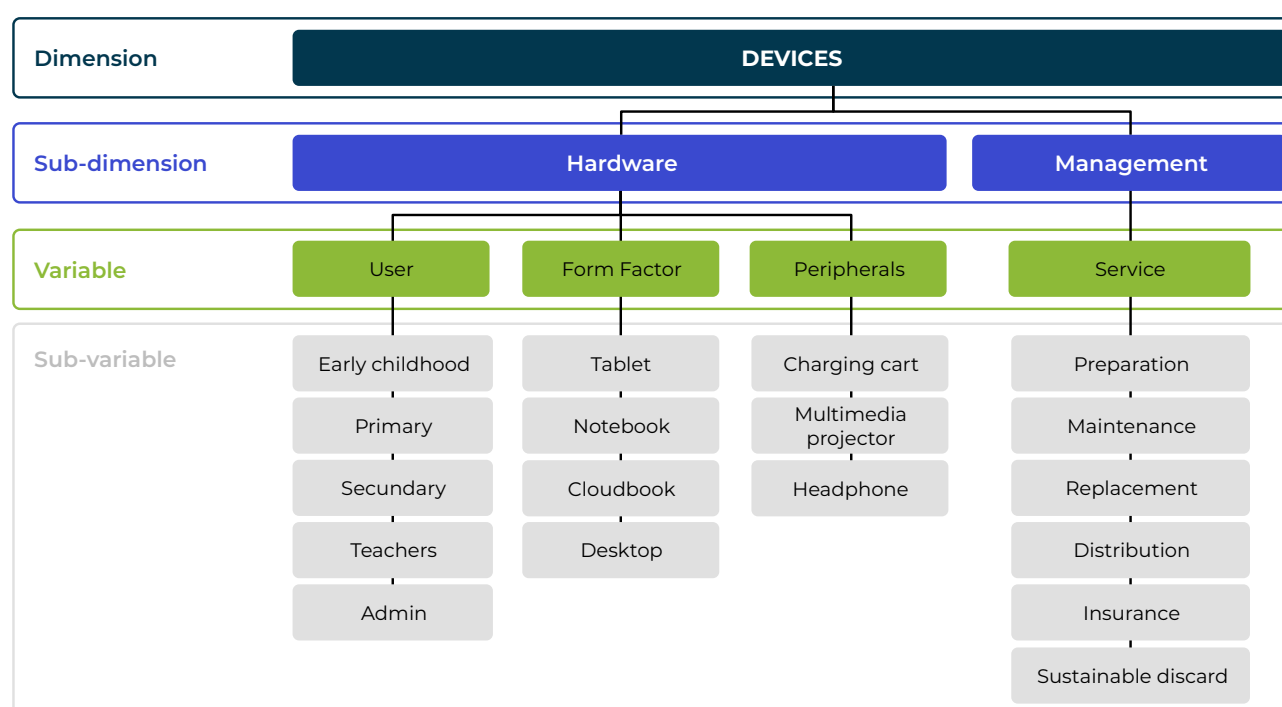


DIMENSION 2

Devices

The integration of digital devices into school environments is a central component for delivering education that meets the demands of the 21st century (OECD, 2021). However, as UNESCO (2021) and the OECD (2021) point out, one of the main challenges for public administrators is making informed decisions about which devices best meet the need of each pedagogical context, as well as accurately determining the appropriate number of devices required per school.

In this context, this dimension is organized around two complementary axes: (i) Hardware — guiding the selection of the most suitable devices and establishing usage criteria based on user profiles; and (ii) Management — encompassing the processes of preparation, configuration, maintenance, and technical support required to ensure the proper functioning and sustainability of equipment over time.



In recent years, education systems have made massive investments in equipping schools, aiming to foster the development of digital competencies in teaching and learning processes and to align schools with an increasingly digital world. Institutional planning envisaged the long-term implementation of a 1:1 device-to-student model, enabling the use of equipment in every lesson. Leading references on the topic recommend integrating technology into daily school life - not only for teaching and learning, but also for management processes.

Nonetheless, programs such as One Laptop Per Child (OLPC) in Peru⁷ demonstrated that simply distributing devices is insufficient to improve academic performance. According to the Inter-American Development Bank (IDB, 2012), while computer access and usage increased, the impact on mathematics and language outcomes was limited; however, the program did lead to greater computer use both at school and at home, along with modest improvements in general cognitive skills such as verbal fluency and logical reasoning. The role of devices in education has since evolved significantly, as highlighted in the ICT Transforming Education report (European Commission, 2019), which identifies full ICT integration as the most advanced stage of school transformation. In this context, the European Union's Highly Equipped and Connected Classroom (HECC) model emphasizes not only technological infrastructure but also teacher training and access to high-quality digital resources, defining different levels of maturity in digital education ecosystems; at the most advanced level, the model recommends one device per student alongside additional learning-focused technologies such as e-readers and virtual reality wearables.

Complementing this view, the World Bank's SABER ICT Framework (World Bank, 2016) outlines four maturity levels in infrastructure - covering electrical systems, devices and network infrastructure, and device support and maintenance. At the highest maturity level, it specifies the need for device access in multiple school spaces, such as classrooms and labs, along with high-speed broadband connectivity.

However, more recent studies warn against excessive device use in schools. The key insight is that more technology does not necessarily equate to higher learning quality; in some cases, overuse can even diminish learning outcomes (OECD, 2015). Two essential factors for successful digital teaching implementation are clear pedagogical intentionality and teachers being fully trained in technology use.

According to a 2015 OECD study, "most educational technologies did not deliver the academic benefits they promised." Meanwhile, global scores in mathematics, science, and reading have been declining (OECD, 2023). Many schools promote

⁷ One Laptop per Child (OLPC) program was launched in 2005 and implemented in 40 countries. A highly publicized initiative that provided personal. A large-scale experimental evaluation of the OLPC program in Peru found no effects on academic achievement or enrollment in primary school after 15 months of program implementation (Cristia et al., 2017).

device use as a sign of “innovation,” without critically examining how those devices are actually used in practice (Tyson, 2024).

The challenge is to use this body of evidence as a reference point—while critically adapting it to local realities (OECD, 2015). After all, technology will remain integrated into students’ daily lives (OECD, 2023), so it is vital that learners are empowered to use it effectively. The real question is not whether screens should be present in schools—but how to incorporate them in ways that develop unique skills or enhance learning, while protecting students from potential negative effects.

Given this context, the following sections will explore key aspects to ensure that the use of digital devices in public education aligns with schools’ pedagogical needs and enhances student learning.

1. Hardware

1.1. Form Factor: Types of Digital Devices

Selecting digital devices for schools requires aligning technology procurement with pedagogical needs and intended classroom use. Different devices support different learning activities: tablets are well suited for reading digital materials, accessing online content, and app-based activities, while laptops and desktop computers are more appropriate for tasks that involve text production, spreadsheets, coding, and other complex projects. Evidence suggests that aligning hardware choices with educational objectives is as important as selecting appropriate software (Digital Learning Now, 2014). In practice, tablets tend to support content consumption, whereas laptops and desktops enable more advanced forms of digital content creation such as writing, graphic design, and audiovisual production.

Student age and mobility considerations also influence device selection. According to the Digital Learning Playbook (Digital Promise, n.d.), tablets are generally recommended for elementary students, while laptops are better suited for secondary education. Tablets, notebooks, and cloudbooks also offer advantages in mobility due to their lightweight and portable design, which is particularly valuable for teachers who need flexible devices for lesson preparation, presentations,

and activities across different school spaces. For computer labs or administrative tasks, desktops and notebooks remain viable options depending on the operational needs of the school.

In this sense, there is no definitive technical rule that determines whether one device is better or worse than another. Ultimately, choosing a type of device will bring benefits or limitations depending on how it is used. See the matrix below:

TABLE 5
Device Type Matrix: Pros and Cons

Device	Pros	Cons	Recommended User
Laptop	<ul style="list-style-type: none"> • Portability • Processing and storage capacity • Wider variety of brands and models • Suitable for intensive tasks, collaboration, and co-creation 	<ul style="list-style-type: none"> • Higher cost • Shorter battery life • Heavier operating system 	<ul style="list-style-type: none"> • Teachers • Administrative staff • Upper secondary students
Cloudbook	<ul style="list-style-type: none"> • Cloud storage • More affordable • Lightweight and portable 	<ul style="list-style-type: none"> • Limited local storage • Relies on high-speed internet • Lower hardware performance compared to notebooks 	<ul style="list-style-type: none"> • Middle secondary students • Upper secondary students
Tablet	<ul style="list-style-type: none"> • Touchscreen, ideal for app-based learning • Lower cost (compared to notebooks and cloudbooks) 	<ul style="list-style-type: none"> • Smartphone-like operating system • Less effective for typing-intensive tasks • Better for content consumption than production or collaboration • Not recommended for upper elementary and secondary students 	<ul style="list-style-type: none"> • Primary or elementary students
Desktop PC	<ul style="list-style-type: none"> • Ideal for tasks requiring high processing power, such as video editing, gaming, or design software • Larger storage capacity • Lower risk of physical damage since it is stationary • Generally offers more power for a lower price than a similarly configured laptop 	<ul style="list-style-type: none"> • Not portable; requires a fixed location • Higher energy consumption compared to mobile devices • Requires dedicated desk space and peripherals (monitor, keyboard, mouse, speakers) 	<ul style="list-style-type: none"> • Administrative staff

Source: Adapted from CIEB et al. (2022).

1.2. User

When it comes to the number of devices per school, the main recommendation aligns with previously established guidelines: technology should be intentionally and thoughtfully integrated into the educational routine. This means considering digital resources as part of the learning process without neglecting other essential activities that contribute to the development of broader skills and competencies beyond the digital environment.

A useful indicator for public managers to monitor whether these principles are being implemented is:

Student-to-Device Ratio

This proportionality indicator is directly linked to planning how frequently devices are used in schools. For example, setting a goal of 2 hours of technology use per student group per week. In practice, the Student-to-Device Ratio functions as a proxy for managing students' screen time, since it reflects how often devices are expected to be used in classroom activities. By defining an expected frequency of technology use, it becomes possible to calculate the minimum number of devices required for each student to use them as planned.

While the specific calculations are detailed in Appendix A, the underlying reasoning for this indicator is relatively straightforward. For example, if the instructional plan allocates technology use to 50% of school time, it becomes feasible to purchase devices for only half of the student population. In practice, this means that while one group of students is engaged in technology-assisted individual activities, the other group participates in unplugged learning. The proposal recognizes that not all learning activities require the simultaneous use of technology, and that a sharing system can generate substantial cost savings. This approach represents an efficient strategy for optimizing public investment, as it ensures equitable access to devices while avoiding unnecessary expenditure.

The following sections will examine what the ideal ratio might be for different groups of students—or whether such an ideal ratio exists at all—while also con-

sidering implications for appropriate screen time in schools.

1.2.1. Early Childhood Education

Early Childhood Education marks the beginning of children's educational journey, serving those up to 5 years and 11 months old. At this stage, pedagogical approaches must recognize the child as the central figure in the educational process, understanding them as active participants in constructing their own knowledge. Through interactions, relationships, and daily experiences, children develop their personal and collective identities. By playing, imagining, exploring, hypothesizing, observing, and communicating, they attribute meaning to the world around them, develop an understanding of nature and society, and participate in the creation of culture from their earliest years (Governo do Brasil, 2012).

The core pillars of pedagogical practices in this stage of Basic Education are interactions and play—experiences through which children can construct and appropriate knowledge based on their actions and interactions with peers and adults, thus enabling learning, development, and socialization.

Regarding technology use at this stage, the World Health Organization (WHO) has established global recommendations aimed at promoting healthy development by encouraging physical activities and direct human interactions, which are fundamental in early childhood (World Health Organization, 2019). The guidelines include:

- **Children under 2 years old:** No screen exposure.
- **Children aged 2 to 5:** Screen time should be limited to no more than one hour per day.

Several studies have examined the consequences of excessive screen exposure during early childhood development. While there is no absolute consensus on the appropriate amount of screen time for children in this age group, there is growing concern among early childhood specialists about understanding the impacts of digital technology use, as children's interactions with these tools have become increasingly common (Santos et al., 2022).

This systematic review suggests that excessive screen time among young chil-

dren may be associated with attention problems. It highlights the role of parents and teachers in managing screen exposure, especially after the widespread use of online classes during the COVID-19 pandemic.

Research consistently shows that excessive screen exposure in early childhood can negatively affect health and development. A review by Kerani, Sher, and Mophosho (2022) found that earlier exposure to screens and longer screen time are associated with poorer language development, while starting exposure at older ages may produce more positive outcomes; the effects also depend on factors such as content type, video characteristics, and whether viewing occurs jointly with adults. Similarly, a meta-analysis by Li et al. (2020) found strong evidence linking excessive screen time among young children and preschoolers to overweight or obesity and shorter sleep duration, with broader impacts on physical, behavioral, and psychosocial health.

Evidence also suggests that the potential risks of touchscreen use in early childhood often outweigh the benefits. Rocha and Nunes (2020) report that for children under five, excessive use of touchscreen devices can contribute to childhood obesity and sleep deprivation, while emphasizing that the quality of child–adult interactions plays a more critical role in development than access to devices. The literature increasingly recommends delaying exposure to screens until at least six years of age, as early childhood is a period of rapid brain development in which sensory, motor, and social experiences are essential. Replacing these experiences with repetitive two-dimensional interactions can limit opportunities for motor exploration, social interaction, and language development (Kerani, Sher, & Mophosho, 2022).

In this context, for early childhood education institutions, internet connectivity and connected devices should be made available **exclusively for education professionals within the school and not for use by children, even when intended for pedagogical activities** (Rocha & Nunes, 2020).

Despite the absence of screen exposure in early childhood classrooms, it is fully possible to develop activities that foster computational thinking (Ministério da Educação, 2022) without the need for devices. Through unplugged activities, for example, the school's teaching staff in Brazil are able to:

- Develop pattern recognition and identification skills by organizing objects based on various criteria such as quantity, shape, size, color, and behavior (Ministério da Educação, 2022).
- Create and test algorithms by playing with physical objects and using body movements, either individually or in groups (Ministério da Educação, 2022).
- Solve problems by decomposing them into smaller parts, identifying steps, stages, or recurring cycles that can be generalized or reused in solving other problems (Ministério da Educação, 2022).

1.2.2 Primary and Secondary Education

The Role of Digital Education

In primary and secondary education, digital technologies play distinct and complementary roles. While in primary education the students are developing greater autonomy and motor skills. During this period, students expand their interactions with their environment and deepen their use of multiple forms of language, including writing and mathematics. In secondary schools foster critical thinking, creativity, autonomy, and responsibility, secondary education schools must provide experiences and processes that ensure the acquisition of essential knowledge. Secondary schools are also tasked with preparing students for both work and citizenship, developing competencies that enable them to engage critically, creatively, and responsibly in an increasingly dynamic and unpredictable professional landscape. Students are thus encouraged to design their life projects and commit to lifelong learning, allowing them to adapt flexibly to new opportunities for employment or further education.

For example at the secondary education, The use of digital technologies can support the development of key skills and competencies, such as:

- Solving complex problems by exploring innovative solutions applicable to the labor market (OECD, 2022);
- Developing digital autonomy by using online learning platforms to expand knowledge and qualifications (OECD, 2022);

- Collaborating in virtual environments through digital tools for communication, project management, and joint decision-making (OECD, 2022);
- Utilizing productivity and automation tools, such as spreadsheets, project management software, and artificial intelligence for workplace optimization (OECD, 2022);
- Understanding digital ethics, including cybersecurity, privacy, and the social and labor impacts of technology (OECD, 2022);
- Acquiring basic programming skills, computational logic, and AI tools to optimize processes and solve complex problems (OECD, 2022);
- Interpreting and analyzing large volumes of data, graphs, and statistical processes to support arguments and decision-making (OECD, 2023b);
- Producing videos, podcasts, interactive infographics, and animations using advanced software, exploring the potential of design and digital communication (OECD, 2023b);
- Conducting research using academic databases, managing bibliographic references, and organizing scientific and technical knowledge with advanced tools (OECD, 2023b).

These skills prepare students for a world where technology is deeply integrated across all fields of knowledge and work, fostering innovation and critical analysis.

The impact and dosage

The impact of digital technologies on education has been widely debated, with studies showing that their effectiveness depends on various factors, including how they are implemented, the amount of screen time, and the educational context. Data analysis from PISA 2018 and other studies reveals that technology can be associated with learning when used moderately and with adequate pedagogical planning. However, excessive use can undermine academic performance and student well-being, highlighting the need for a balanced approach

that combines innovation with sound teaching practices.

According to the article “New global data reveal education technology’s impact on learning” (Bryant et al., 2020), the way educational technology is integrated into the learning experience is crucial to its effectiveness. The study analyzed PISA 2018 data from over 340,000 students across 51 countries, evaluating student performance in reading, mathematics, and science. The findings suggest that students who used digital devices for more than 60 minutes per subject per week showed improved learning outcomes (Bryant et al., 2020).

However, the same study shows that PISA 2018 reading results reveal significant regional variation in the impact of device use in classrooms, depending on the level of development of educational systems. In some regions, technology use is associated with a decline in academic performance, while in others, it yields gains of up to 17 PISA points — equivalent to nearly half a year of learning. This is because education systems in early stages of development — characterized by limited infrastructure, insufficient teacher training, low average student performance, and weak educational policies — are not yet prepared to integrate technology effectively. In such contexts, the presence of devices without proper support may hinder rather than help learning.

These results emphasize that technology is not a silver bullet for educational challenges, but a tool that should be integrated thoughtfully into the education system. A critical factor in this integration is dosage—the amount and frequency of student engagement with digital learning. The literature shows considerable variation: session lengths reported range from 20 minutes (Beg et al., 2022) to 90 minutes (Araya et al., 2019), and frequency from twice a week to six times a week (Muralidharan et al., 2019). References on dosage can be found in Appendix B.

Evidence on the impact of increased dosage is mixed. For example, a study in Russia found no significant learning gains from doubling the length of a student-facing intervention (Bettinger et al., 2023). However, many interventions with positive outcomes involved daily use of around 25–30 minutes. Large-scale data from PISA 2022 adds complexity: moderate device use at school for learning is associated with higher mathematics scores, but very high usage, over five hours daily, is linked to lower performance (OECD, 2023).

Overall, the findings indicate that simply spending more time on a platform does not guarantee better outcomes. However, a minimum level of consistent engagement is necessary, as sporadic use rarely produces meaningful learning gains. In response, digital learning policies are shifting away from the idea of fully digital classes and increasingly incorporating guidelines—and even screen time limits—to ensure balanced use.

Costa Rica implemented the Laboratorio de Informática Educativa – PRONIE (Villalobos García et al., 2022), an educational initiative aimed at fostering problem-solving, collaboration, creativity, and digital literacy among students. The program allocates 80 minutes per week in a dedicated computer lab, guided by a specialized Information Technology teacher. In China, for instance, the Ministry of Education established guidelines limiting screen-based learning to no more than 30% of total instructional time and restricting homework on digital devices to no more than 20 minutes per day. The guidelines also recommend that students rest their eyes for 10 minutes after every 30 to 40 minutes of screen use for educational purposes (Wong et al., 2021). While countries continue investing in educational technologies, many are simultaneously setting boundaries to ensure their effective and responsible use.

In conclusion, although there is broad consensus that instruction should not be fully digital, there is no agreement on the optimal amount of screen time. The studies cited above present considerable variation in recommendations, ranging from approximately 30 minutes per day to four hours per week. It is important to highlight that positive outcomes appear to be associated not only with the dosage itself but also with several other contextual factors. The GEM Report (UNESCO, 2023) emphasizes that the impact of digital technology is incremental, uneven, and more pronounced in some contexts than in others. Its effectiveness depends on variables such as community and socioeconomic conditions, teacher readiness and willingness, education level, and national income.

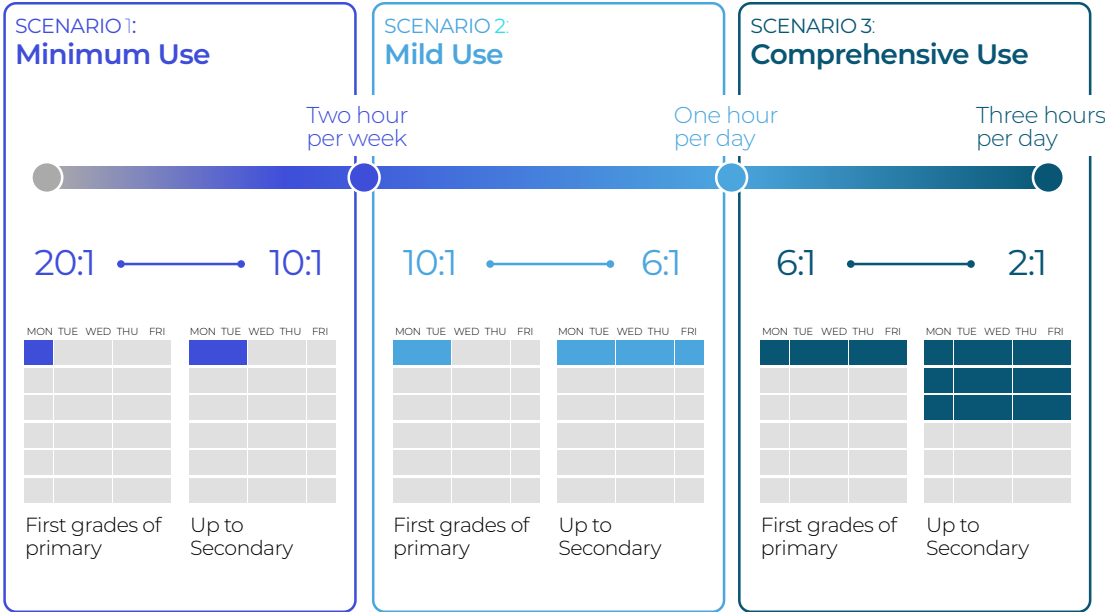
Parameters

These results highlight that technology is not a unique solution to educational challenges and that its effective implementation requires planning, adequate teacher training to use and mediate technology in learning processes, and adaptation to local realities. Therefore, establishing a unique parameter for the stu-

dent device ratio seems not feasible or wise. Therefore, we suggest three different options - minimum use, moderate use and comprehensive use.

TABLE 6
Recommended Amount of Time for Device Use in Class

	Minimum Use	Moderate Use	Comprehensive Use
Student/Device	Primary: 20:1 Secondary: 10:1	Primary: 10:1 Secondary: 6:1	Primary: 6:1 Secondary: 2:1
How many hours per week^a, approximately	Primary: 1 hour Secondary: 2 hours	Primary: 2 hours Secondary: 5 hours	Primary: 5 hours Secondary: 15 hours
% of school time using devices, approximately	Primary: 3% Secondary: 7%	Primary: 7% Secondary: 17%	Primary: 17% Secondary: 50%



Source: Authors

^a An estimate, considering a school-time of 6 hours a day.

To define a scale for technology use in learning, it's essential to balance pedagogical impact, operational feasibility, and costs. The presented framework offers three scenarios: **Minimum Use**, **Moderate Use**, and **Comprehensive Use**, each with specific recommendations for student-to-device ratios and approximate weekly usage hours. The **Minimum Use** scenario proposes a conservative approach, with primary students using devices for one hour per week and secondary students for two hours. This model treats technology as a complement to traditional teaching, but may limit the development of advanced digital skills. The **Moderate Use** scenario fosters greater immersion, recommending primary students use devices for two hours per week and secondary students for five hours. This approach enables deeper learning through collaborative projects and personalized pathways, requiring greater investment in infrastructure and careful pedagogical planning.

The **Comprehensive Use** scenario positions technology as a central element of the curriculum, with primary students using devices for five hours per week and secondary students for up to fifteen hours. This level of engagement reflects the growing complexity of skills required at higher educational stages. This approach tends to enhance digital fluency and expand opportunities for educational innovation (Villalobos García et al., 2022). However, it demands greater investments in infrastructure, device maintenance, and careful pedagogical planning to ensure that technology complements rather than replaces other effective teaching methods.

The recommended screen time also considers that, as students progress through educational stages, technology use should become more frequent, reflecting the growing complexity of the skills and competencies expected, particularly at the secondary level. Therefore, the proposed timeframes are designed to meet the pedagogical needs of different age groups while prioritizing accessibility, practicality, and alignment with educational goals—without exposing students to excessive screen time.

Regardless of the chosen scenario, ultimately, the choice of scenario should be driven not by financial constraints alone, but by a consideration of the potential educational impact and the capacity of the institution to effectively implement the strategy.

1.2.3. Devices for Teacher Use

For effective digital learning implementation, teachers must be able to integrate technology across their pedagogical practices. This requires them to be equipped to adapt their teaching approaches to contemporary educational demands.

According to the GEM Report (UNESCO, 2023a), the use of computers in the classroom is essential for teachers to meet modern educational needs and offer richer, more diversified learning experiences. With a device, teachers can access a wide array of digital resources—including interactive presentations, educational videos, simulations, and online learning platforms—that make lessons more dynamic. Technology also plays a crucial role in personalizing instruction, helping educators address students' specific learning needs and fostering a more inclusive and effective learning environment (UNESCO, 2023a).

In addition to classroom use, devices are critical for school management tasks, such as attendance tracking and grade recording. Dedicated software and digital spreadsheets enable teachers to organize this information efficiently and securely, reducing time spent on administrative duties. Moreover, digital tools streamline communication with school staff and families, improving transparency and facilitating the monitoring of student performance and attendance (UNESCO, 2023a).

The GEM Report (UNESCO, 2023a) highlights that teachers are expected to incorporate technology into various aspects of their professional activities. This includes instructional methodologies, student assessment, communication with learners and their families, and their own professional development. Effective technology integration empowers teachers to adopt student-centered practices, create dynamic and meaningful learning environments, and equip students with critical digital competencies.

Teacher development in and through technology should therefore enable educators to act as creators, designers, and facilitators—especially when selecting the most appropriate technologies to address the diverse needs and contexts of learners, both inside and beyond the classroom.

In this regard, the recommended standard for teacher devices, according to the GEM Report (UNESCO, 2023a), is:

1 device per teacher

This recommendation acknowledges that teachers engage in professional tasks that require technology use both within the classroom and in broader instructional and administrative contexts.

TABLE 7
Use of Technology by Teachers

Use in the Classroom	Use outside of the Classroom
<ul style="list-style-type: none"> • Content projection • Use of simulation software • Guided research • Use of interactive games • Collaboration in online projects 	<ul style="list-style-type: none"> • Lesson planning • Continuous professional development • Preparation of tests and activities • Management of grades and attendance • Preparation of teaching materials • Communication with students and families • Participation in online meetings

Source: Authors

1.3. Peripherals

Peripherals are complementary devices that, while not the central element of a digital education policy, significantly enhance the user experience and support effective technology integration in schools. Their role is to ensure that devices can be used safely, efficiently, and in ways that maximize both teaching and learning outcomes. By including peripherals in planning, education systems move beyond simple device provision to creating the conditions for sustainable and pedagogically meaningful digital use.

Three types of peripherals are considered particularly relevant. Charging carts are essential for the safe storage, protection and recharging of devices, particularly in schools where students do not take devices home (which is the path we are taking in the three scenarios of student devices.). A recommended standard is one charging cart for every thirty student devices, which aligns with common classroom sizes and ensures daily availability of equipment. Multimedia projectors are recommended at a ratio of one per school. They support collective teaching practices, facilitate the display of digital content to large groups, and are especially valuable in contexts where interactive whiteboards or advanced classroom displays are not yet available. Headphones are recommended on a one-to-one basis, with each student device accompanied by an individual headset. This provision allows for personalized learning experiences, supports inclusive practices such as accessibility for students with special needs, and minimizes classroom noise.

By adopting these standards for peripherals, governments and education authorities can strengthen the implementation of digital learning strategies, ensuring that the infrastructure provided not only places devices in schools but also creates environments where their pedagogical potential can be fully realized.

2. Device Management

The management of devices is a fundamental sub-dimension for ensuring that investments in digital education translate into meaningful and sustained learning outcomes. While the provision of hardware is often the most visible element of digital initiatives, their long-term effectiveness depends on a robust set of management practices that guarantee continuity, reliability, and sustainability of use across the education system.

The process begins with preparation, which involves configuring devices with the necessary operating systems, security measures, and educational software before they are deployed to schools. This step reduces the administrative burden on teachers and ensures that students and staff can immediately engage with technology for learning and management tasks. Without systematic preparation, devices often remain underused or inconsistently integrated into teaching practice.

Once devices are in use, maintenance becomes essential to address both routine and unexpected technical issues. Schools frequently face disruptions when

devices malfunction, and without adequate technical support, breakdowns can lead to long periods of inactivity and wasted resources. Preventive maintenance routines, combined with rapid-response repair systems, are therefore indispensable to safeguard instructional time and preserve trust in digital tools.

Equally important is replacement, which acknowledges that devices have finite lifespans and that technological obsolescence can undermine learning objectives. Establishing clear replacement cycles and budgeting mechanisms ensures that students and teachers have access to functional and up-to-date technology, rather than relying on outdated or unreliable equipment.

Effective distribution is another key management element, as devices must reach their intended users in an equitable and timely manner. In many education systems, inefficiencies in logistics have delayed or undermined technology rollouts, especially in rural or underserved areas. Clear distribution strategies help prevent such disparities and contribute to more inclusive access to digital learning.

The role of insurance within device management is often underestimated, yet it provides a financial safety net for schools and governments. By covering losses and damages—whether from accidents, theft, or natural disasters—insurance mechanisms reduce the vulnerability of digital education programs and protect long-term investments.

Finally, sustainable discard addresses the environmental dimension of digital transformation. As devices reach the end of their useful lives, it is essential to ensure their disposal follows principles of environmental sustainability, including recycling and safe handling of electronic waste.

It is important to note that the calculator does not individually account for these management items. This choice reflects two considerations: first, the extent of management costs often depends on the government's existing infrastructure and capacity; and second, many of these expenditures are embedded within the overall costs of hardware acquisition and operation. Nonetheless, the importance of management should not be overlooked, as it constitutes the foundation for the reliability, sustainability, and equity of digital learning initiatives.

TABLE 8
Lifecycle of devices

Life Cycle stage	Purpose	Key actions	Responsible actors	Challenges	Recommendations
1. Acquisition	Strategic selection and purchase of devices aligned with pedagogical needs.	<ul style="list-style-type: none"> Define user profiles (students, teachers, admin). Choose device type (tablet, laptop, cloudbook, desktop). Evaluate cost-benefit and technical specs. Plan for 1:1 or shared-use models based on pedagogical goals. 	Education authorities, procurement agencies, ICT specialists.	<ul style="list-style-type: none"> Mismatched device types. Insufficient budget planning. Lack of pedagogical alignment. 	<ul style="list-style-type: none"> Align procurement with intended pedagogical use (OECD, 2021). Prioritize value over volume. Adopt cost-sharing models.
2. Preparation	Configuration and readiness of devices before deployment.	<ul style="list-style-type: none"> Install OS and security software. Preload educational apps and content. Tag and inventory devices. Create maintenance and warranty records. 	ICT teams, technical partners, local education departments.	<ul style="list-style-type: none"> Delayed configuration. Lack of standardization. Security vulnerabilities. 	<ul style="list-style-type: none"> Centralized preparation hubs. Use management software (MDM) Establish baseline configurations for all schools.
3. Distribution	Equitable and timely delivery of devices to intended users.	<ul style="list-style-type: none"> Plan logistics to reach all schools, including remote ones. Ensure safe transport and insurance coverage. Verify receipt and proper installation. 	Ministries, local education authorities, logistics partners.	<ul style="list-style-type: none"> Delays in delivery. Unequal distribution (urban vs rural). 	<ul style="list-style-type: none"> Map schools and needs in advance. Monitor distribution through digital tracking. Include insurance to protect investments.
4. Use	Integration of devices into teaching, learning, and management.	<ul style="list-style-type: none"> Preventive maintenance and regular updates. Provide local or remote technical support. Establish repair timelines. Renew software licenses. 	ICT departments, service providers, school tech leads.	<ul style="list-style-type: none"> Long repair times. Lack of spare parts. Insufficient technical staff. 	<ul style="list-style-type: none"> Implement centralized helpdesk. Schedule preventive checks. Use warranty and service contracts.

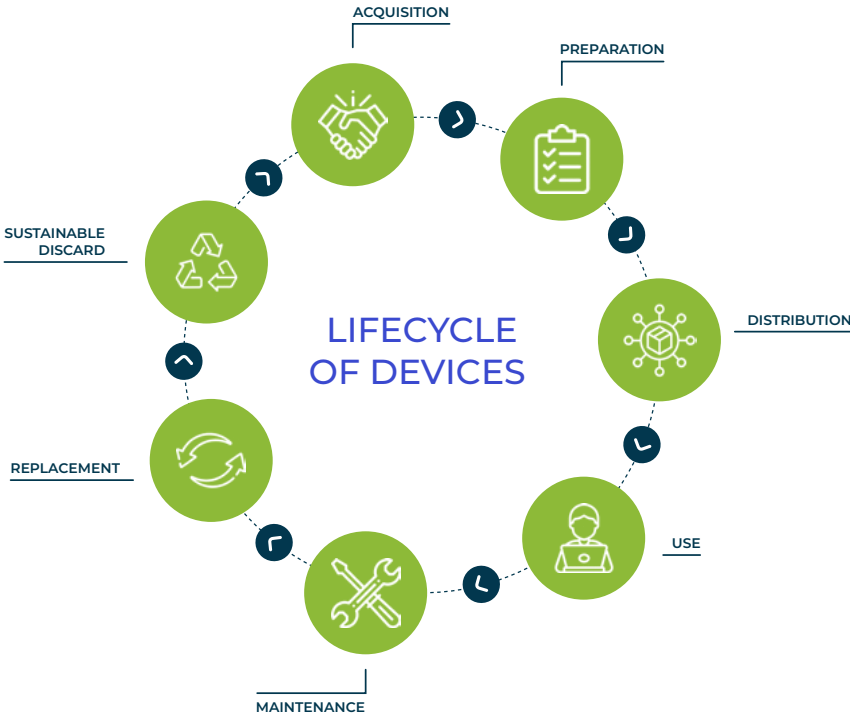
Digital Learning Cost Calculator

<p>5. Maintenance Ensures devices remain functional and secure throughout their lifespan.</p>	<ul style="list-style-type: none"> Align technology with curriculum goals. Train teachers in digital pedagogy.- Manage screen time and student-device ratio. Encourage creative and collaborative use. 	<p>Teachers, students, pedagogical coordinators.</p>	<ul style="list-style-type: none"> Overuse or misuse of screens. Insufficient teacher readiness. Poorly designed activities. 	<ul style="list-style-type: none"> Moderate, purposeful use (OECD, 2023). Follow ratio models (e.g., 10:1 to 2:1). Limit screen time by age group (WHO, 2019).
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<p>6. Replacement Renewal of obsolete or damaged devices to sustain program continuity.</p>	<ul style="list-style-type: none"> Define replacement cycles (3-5 years typical). Budget for gradual renewal. Reallocate functional devices. 	<p>Education authorities, finance departments.</p>	<ul style="list-style-type: none"> Unplanned obsolescence. Budget constraints. Disposal of outdated tech. 	<ul style="list-style-type: none"> Plan multi-year replacement funds. Standardize models to reduce costs. Track performance and usage data.
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<p>7. Sustainable Discard Environmentally responsible disposal or recycling of end-of-life equipment.</p>	<ul style="list-style-type: none"> Collect obsolete or non-repairable devices. Recycle components safely. Partner with certified e-waste recyclers. Maintain data security before disposal. 	<p>Governments, certified recycling firms, environmental agencies.</p>	<ul style="list-style-type: none"> E-waste accumulation. Lack of recycling infrastructure. Data leakage risks. 	<ul style="list-style-type: none"> Adopt green ICT policies. Promote refurbishment and reuse. Secure data erasure protocols.
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Source: Authors



2. Summary Table

Therefore, for the devices dimension the calculator shows the cost for the following items:

TABLE 9
Overview of the Devices Dimension

Subvariable	Parameter	Quantity
Devices – Students – Min	Primary: 1 device per 20 students Type: Tablet Secondary: 1 device per 10 students Type: Cloudbook	Number of Primary Students Number of Secondary Students
Devices – Students – Mild	Primary: 1 device per 10 students Type: Tablet Secondary: 1 device per 6 students Type: Cloudbook	Number of Primary Students Number of Secondary Students
Devices – Students – Comprehensive	Primary: 1 device per 6 students Type: Tablet Secondary: 1 device per 2 students Type: Cloudbook	Number of Primary Students Number of Secondary Students
Devices – Teachers	1/teacher Type: Laptop	Number of Teachers
Devices – Admin	1 per school	Number of schools
Charging Cart – Min	1 per 30 devices	Number of devices in Min scenario
Charging Cart – Mild	1 per 30 devices	Number of devices in Mild scenario
Charging Cart – Comprehensive	1 per 30 devices	Number of devices in Comp scenario
Multimedia Projector	1 per school	Number of Schools



DIMENSION

3

Teacher Training

Digital transformation in education cannot happen without educators who are prepared to use digital tools (UNESCO, 2023a). Teachers are the key to this process. They are the ones who decide how, when and why digital tools are integrated into teaching and learning. Nowadays, their role is to ensure that technology remains a means to an end, not the end itself, fostering deeper learning rather than simply digitizing traditional practices (OECD, 2025).

Given that teacher training is essential for incorporating technology into the classroom, many countries have developed frameworks and programs to strengthen teachers' digital competencies. These frameworks are seen across the world as the guiding compasses for successful digital integration.

The European DigCompEdu model, with its six proficiency levels, offers a clear roadmap for developing pedagogical skills. In Latin America and the Caribbean, the IDBs EduTec Guide⁹ serves as a diagnostic and self-assessment tool, already applied to teachers across eight countries, helping policymakers design more evidence-based interventions (CIEB/IDB, 2023). In the following sections, we will delve deeper into the two tools and explain why they are key references for our technical note.

Professional learning that follows diagnosis must be embedded, content-focused, sustained, and collaborative; as the OECD (2025) notes, these are the hallmarks of impactful teacher development. Yet, emerging technologies such as generative AI now demand an even deeper renewal of digital pedagogy. Teacher training policies must evolve continuously to ensure educators are equipped not only to use technology, but to shape it toward ethical and effective learning experiences (Villegas Reimers et al., 2023). Here are four examples of teacher training policies across the region:

⁹ EduTec Guide, based on the framework designed by CIEB in Brazil is a free resource that helps teachers assess their digital skills and receive a personalized training plan. Learn more: <https://knowledge.iadb.org/en/code-development/open-source-solutions/edutec-guide>

TABLE 10
Overview of Different Training Programs

Country	Program	Key Features	Main Takeaways
Argentina	INFoD – Instituto Nacional de Formación Docente	Offers large-scale virtual courses on ICT integration for teachers across all education levels. Focuses on pedagogical inclusion and collaborative online environments.	Continuous education, flexible virtual learning, empathetic tutor-led models, emphasis on pedagogical—not just technical—use of technology.
Uruguay	Plan Ceibal	Global reference in digital inclusion, offering blended courses, mentorships, and scholarships for teacher trainers.	Strong diagnostic basis, interdisciplinary curriculum, and competency-based framework guiding hybrid education.
Peru	Aula Digital Peru	Implemented in 21 regions, combining field mentoring, local coordination, and national frameworks.	Situated learning model, community engagement, integration of local and international competency frameworks.
Costa Rica	PRONIE MEP-FOD	Partnership between the Ministry of Education and Fundación Omar Dengo to integrate ICTs in schools since 2011.	Long-term collaboration between public and private sectors, blended learning, and regional advisor networks supporting teachers.

Source: adapted from Villegas Reimers et al., 2023

Countries investing in structured diagnostics and teacher capacity building are not only strengthening their education systems, they are future-proofing them. By starting with accurate data, policymakers can design targeted pathways that make every training program relevant, efficient and equitable (Villegas Reimers et al., 2023).

Around the world, governments have designed distinct programs and frameworks that reflect different priorities, infrastructures and pedagogical traditions. Each presents unique models, advantages and trade-offs.

In Peru, the Aula Digital program, launched in 2018 by Fundación Telefónica in

collaboration with the Ministry of Education, demonstrates how diagnostics can underpin scalable and contextually relevant teacher training initiatives. Operating in 21 regions and involving over 14,000 teachers and principals, the program began by mapping digital skills across schools to tailor professional learning pathways (Villegas Reimers et al., 2023)

The initial diagnostic revealed wide disparities in digital readiness among teachers (Fundación Telefónica Perú & UNESCO Perú, 2021), prompting the development of a progressive, three-level training model. The curriculum was structured around four key capabilities: informational literacy, communication and collaboration in digital environments, digital content creation, and the pedagogical use of technologies (UNESCO, 2019; Redecker & Punie, 2017). All of them are aligned with the UNESCO ICT Competency Framework for Teachers (UNESCO, 2019) and Peru's Marco de Competencia Digital Docente (MINEDU, 2020).

Another important example, Uruguay's Plan Ceibal stands out as a global reference for comprehensive digital inclusion and teacher training. Initially launched to guarantee universal device and connectivity access, Ceibal has evolved into a sophisticated professional development ecosystem that integrates diagnosis, training, mentoring and evaluation (Villegas Reimers et al., 2023).

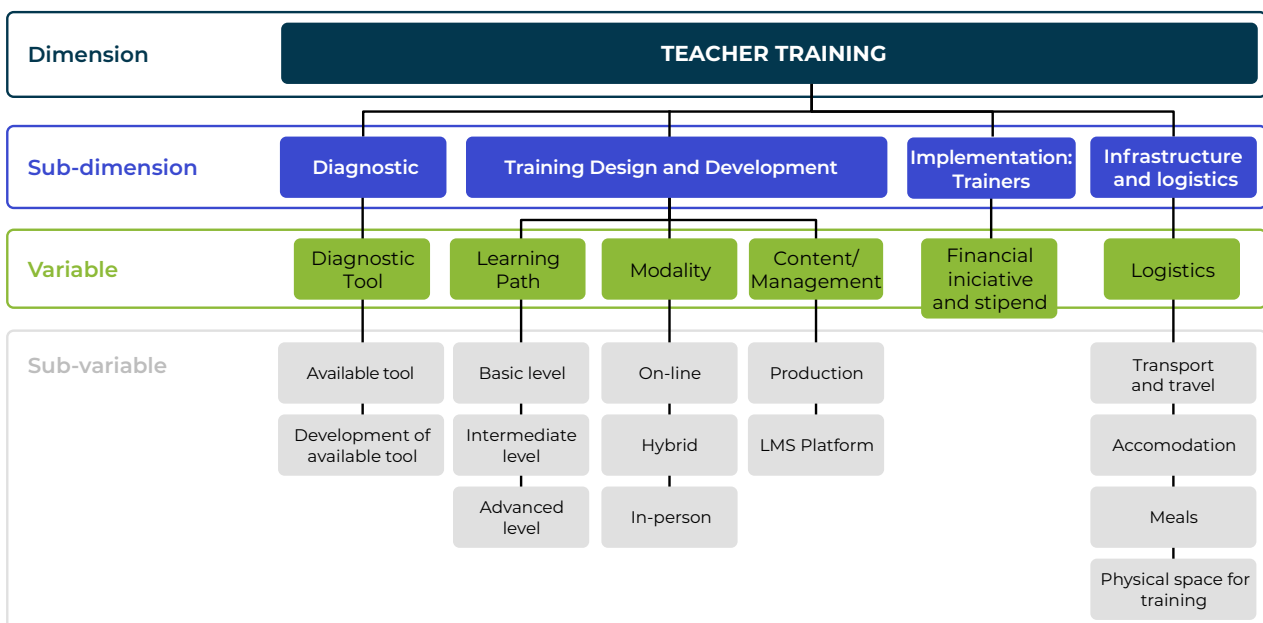
Key Structural Aspects for Teacher Training Programs

Although the examples differ across contexts, common structural aspects have been identified as essential for the successful design and implementation of teacher training initiatives. The following aspects should be taken into account:

- 1. Diagnosis of current needs:** An assessment to understand the existing digital skills levels of teachers and the specific areas where training is most needed. An accurately validated assessment tool ensures that the information gathered is relevant and can be used to design training programs that address the real challenges faced by educators.
- 2. Design of training programs:** The design of a training includes creating a program structure, selecting appropriate training modalities, defining the learning objectives and producing the content.

3. Ensuring adequate trainers: The process of recruiting, hiring and providing instructors or trainers who will lead the teacher training sessions guarantees the quality of participants’ learning outcomes.

4. Infrastructure and logistics for in-person training: When the teacher training programs include in-person components, ensuring that all necessary resources are in place is important. This includes providing appropriate training venues, transport, devices and overall amenities to facilitate a smooth and effective learning experience for all participants.



1. Diagnosis

Before designing professional development pathways to strengthen teachers’ digital competencies, education systems in Latin America and the Caribbean must first assess teachers’ current levels of digital proficiency. Conducting such diagnostics is essential to ensure that training programs respond to teachers’ actual needs and make efficient use of resources. Diagnostic tools are therefore a strategic component for designing effective professional development policies (Fullan & Langworthy, 2014). This is particularly important in LAC, where a large proportion of teachers remain at early stages of digital proficiency, as documented by the IDB (Della Nina Gambi et al., 2025), UNESCO (2023a), and CAF (Zacarias, 2023).

Evidence highlights the scale of this challenge. The IDB and ProFuturo found that in six Latin American countries only 27% of teachers reached the basic level of digital proficiency required for pedagogical use of technology (Della Nina Gambi et al., 2025). Similarly, a study across Chile, Ecuador, Mexico, and Peru showed that 46% of teachers performed below the minimum proficiency threshold (Zacarias, 2023). Without accurate diagnostics, professional development initiatives risk adopting one-size-fits-all approaches that fail to address teachers' actual strengths and gaps, potentially reducing effectiveness and reinforcing existing inequalities (Villegas Reimers et al., 2023).

Several countries have begun incorporating structured diagnostics as the first step in their teacher training strategies, enabling more personalized and progressive learning pathways adapted to diverse teaching contexts. Uruguay provides a notable example: through Ceibal and the Global Learning Network, the country developed a competency-based diagnostic framework linking technology and pedagogy, which helped institutionalize digital skills as a core component of teacher professional development (Villegas Reimers et al., 2023). Such approaches position diagnostics as a cornerstone of digital transformation in education systems, helping ensure that teachers can lead—rather than lag behind—the integration of technology in teaching and learning.

1.1. Diagnostic tools

Therefore, before launching large-scale training initiatives, education systems must first understand teachers' current level of digital competence. To do so, it is essential to have a tool that can accurately measure existing skills and identify specific needs.

When diagnostic tools are well-designed and validated, they become powerful instruments for strategic planning and policy coherence. They guide training programs that are personalized, progressive, and context-sensitive, ensuring that teachers evolve at their own pace while maintaining systemic alignment. This approach strengthens not only digital competencies but also the equity and sustainability of education systems.

One prominent example is the Edutec Guide¹⁰, launched by the Inter-American

¹⁰ Learn more: Inter-American Development Bank. (s.d.). Edutec Guide.

<https://knowledge.iadb.org/es/conocimiento-abierto/codigo-para-el-desarrollo/solucion-de-codigo-abierto/guia-edutec>

Access the Edutec Guide: <https://edutec.iadb.org/register>

Development Bank (IDB) and inspired by an open-source model developed by CIEB (Innovation Center for Brazilian Education) in Brazil. This free, online, and customizable tool allows teachers across Latin America and the Caribbean to self-assess their digital competencies in three core areas: pedagogy, digital citizenship and professional development.

This tool also points the way to open resources for teachers to strengthen the integration of technology into applied to student learning, the development of their own digital skills and management of digital transformation at schools. The platform offers three distinct entry points: Teacher, Educational Center, and Educational Network, allowing both individualized self-assessment and system-level analysis.

Through a concise 23-question survey, educators receive personalized formative reports that highlight their proficiency levels and recommend curated learning resources to strengthen their digital skills. The Edutec Guide's reach continues to expand: by 2025, it had been implemented across Colombia, Honduras, Nicaragua, Ecuador and other countries. This effort has resulted in over 7,000 teachers participating in the digital skills self-assessment and more than 500 schools completing the technology adoption diagnosis (Della Nina Gambi et al., 2025).

Portugal's Case: From Diagnosis to Policy

Portugal's Digital Transition Plan for Education offers a valuable example of how diagnostics and training can work hand in hand. By using teacher competency assessments, the country was able to identify challenges early, design relevant workshops, and tailor training to real classroom needs (Villegas Reimers et al., 2023).

Countries that effectively integrate diagnostic tools into national education strategies are better positioned to plan long-term digital transitions. When diagnostic data informs policymaking, governments can prioritize investments, align training curricula with classroom realities, and monitor progress through measurable indicators.

Moreover, validated digital tools help ensure transparency and account-

ability in how public funds are used for teacher development. They also strengthen international comparability and cooperation by allowing systems to benchmark their progress.

Ultimately, transforming teacher training through digital diagnostics is not just a technical reform — it's a strategic policy shift toward smarter governance, inclusive innovation, and sustainable educational change.

Key lessons from Portugal include:

- Integration of diagnostic tools enables policymakers to better understand teachers' difficulties and design more targeted solutions.
- Contextualized training ensures that teachers can immediately apply what they learn in their own classrooms.
- Collaborative communities of teachers and trainers foster a culture of sharing, mutual support, and ongoing professional growth.
- ICT integration in pedagogy helps teachers move from basic digital literacy toward innovative teaching practices.
- Portugal's experience highlights that successful digital transformation requires structured, data-driven professional development anchored in diagnostic insights.

Source: (Villegas Reimers et al., 2023)

2. Training Design and Development

Following the results of the diagnosis, the next step is to design a training program relevant and appropriate considering the teacher's current skills. . As highlighted by the OECD (2025), effectively integrating digital technologies into classroom practice requires much more than technical proficiency.

Central to this design is a tiered system, where teachers are assigned to levels that match their current skills. This approach allows educators to build foundational competencies before advancing to more complex challenges, while also accommodating different starting points, experiences, and professional realities.

2.1. Training Pathway

The pathway is structured around a tier system that is progressive and adaptable, ensuring that each teacher receives training that is relevant to their needs. Teachers must be capable of adapting digital tools to specific subject matter and pedagogical objectives (OECD, 2020). The tiered approach supports this process by combining basic, intermediate and advanced levels of development, which helps teachers move from basic digital literacy to the effective pedagogical use of technology.

The Digital Learning Cost Calculator offers two duration options: 60 hours or 40 hours, a workload consistent with international evidence (European Commission, 2017), which indicates that programs of 50–70 hours generate meaningful changes in teaching practices.

The 60-hour pathway is the recommended reference for teachers who require substantial strengthening of their digital competencies. The 40-hour alternative recognizes two realities in many education systems: a large share of teachers already demonstrate intermediate or advanced digital skills; available time for in-service training is often limited (Moriconi et al., 2017).

In many systems, the 40-hour and 60-hour pathways also align with certification requirements used for career progression. These certificates are recognized in several countries and function as an additional incentive for participation (OECD, 2025). The Calculator's expectation is that teachers who complete the planned workload over the four-year cycle can access formal recognition that fosters engagement and improves adherence to the training pathway.

The broader literature also emphasizes that, although findings vary and both short and long-duration programs have demonstrated positive effects on student learning, there is strong consensus that effective professional development should be prolonged, intensive, continuous, allowing teachers frequent contact with trainers (Moriconi et al., 2017). This principle guided the design of the Calculator's pathway. This standardization also supports planning, scalability, and budget predictability, while still allowing for personalization (Moriconi et al., 2017).

Importantly, the 60- and 40-hour pathways represent the total training load over

a four-year period. This structure enables systems to distribute activities gradually, supporting sustained competency development while accommodating teachers' time constraints (Moriconi et al., 2017). The Calculator also recognizes that implementation strategies differ across education systems. For instance, under the 60-hour scenario, a system might choose to train all teachers for 15 hours per year over four years, or alternatively, train 25% of teachers for the full 60-hour load each year. The 40-hour scenario follows the same logic, allowing systems to allocate 10 hours per year to all teachers, or to train one quarter of teachers for the full 40 hours annually, depending on local planning needs.

Greece – “B-Level ICT Teacher Training”

Greece has launched a large-scale national program designed to enhance teachers' digital education competencies through a tiered certification system (OECD, 2025). The B1 level introduces educators to digital tools and fosters awareness of their pedagogical applications, while the B2 level focuses on deeper subject-specific integration and practical use of educational software and online platforms. The program also includes reflective sessions where teachers discuss ICT use in the classroom (OECD, 2025).

2.2. Modality

The choice of delivery modality - online, in-person, or hybrid - shapes both pedagogical effectiveness and cost.

- **Online:** Maximizes flexibility and scalability, especially in remote areas, but risks lower engagement if not well designed (Villegas-Reimers et al., 2023).
- **In-person:** Fosters interaction, experimentation and peer learning, but is costly and difficult to scale in large or dispersed systems (OECD, 2025).
- **Hybrid:** Combines the strengths of both, balancing flexibility, engagement, and cost efficiency (Villegas-Reimers et al., 2023).

The choice among online, hybrid, or face-to-face modalities directly influences operational and structural costs — and therefore must be made strategically.

Planning teacher training in digital competencies requires more than just content considerations: it is essential to understand the financial impact of each delivery model.

The OECD (2025) report points out that, despite its advantages, fully online courses may be less effective than in-person or hybrid formats. Experience also shows that engagement in online learning programs often encroaches on teachers' personal time, which may discourage participation (OECD, 2025). Digital continuing professional learning activities for teachers therefore need to be carefully designed to ensure that online provision does not come at the cost of quality or accessibility.

In this context, the hybrid model emerges as a strategic alternative by combining the flexibility of the online format with the value of in-person interactions. Researchers such as Villegas-Reimers (Villegas-Reimers et al., 2023), demonstrate that this combination supports better knowledge retention and allows for the personalization of learning according to each teacher's needs. Additionally, this model tends to be more balanced in terms of costs and offers good scalability, making it a viable alternative from both pedagogical and financial perspectives.

Moreover, the hybrid model allows for content adaptation to local realities, respecting each teacher's level of experience and fostering more effective learning pathways. By making choices that optimize investments without compromising learning outcomes, education networks increase their chances of delivering training that genuinely transforms pedagogical practice.

Pilot initiatives in Brazil confirm these trade-offs. The Mato Grosso Teacher Training Program, launched in 2022, mapped teachers' digital competences using the EduTec Guide diagnostic tool and offered hybrid training across pedagogy, citizenship, and professional development. Nearly 20,000 teachers participated in courses of around 66 hours (Fundação Telefônica Vivo, 2022). The program demonstrated that hybrid pathways can adapt content to different contexts while maintaining scale and quality.

Given these considerations, it is recommended that decision-makers carefully assess the pros and cons of adopting a hybrid training model. This approach can help balance pedagogical quality with implementation feasibility, offering wid-

er reach, greater flexibility, and better alignment with teachers' schedules while supporting more sustained learning processes. At the same time, logistical costs (particularly those associated with in-person components) are not detailed in this estimate and can vary greatly across regions and networks. To obtain a more accurate picture of total investment, each context should review its own logistical conditions.

The following table summarizes some of the main advantages and challenges of each modality:

TABLE 11
Pros and Cons of Training Delivery Modalities

Modality	Pros	Cons
Online	<ul style="list-style-type: none"> Enables scale and geographic reach. Reduces travel and accommodation costs. Allows flexible schedules. (Bohne et al., 2024; Global Partnership for Education, 2025) 	<ul style="list-style-type: none"> May reduce engagement if poorly designed. (Mulaimović et al., 2025; Fütterer et al., 2024) Depends on digital access and connectivity. (Hennessy et al., 2022) Can overlap with teachers' personal time.
In-person	<ul style="list-style-type: none"> Strengthens interaction and peer learning. Facilitates hands-on practice. Supports collaborative reflection. (Darling-Hammond et al., 2017) 	<ul style="list-style-type: none"> Involves higher logistical and transportation costs. (UNESCO, 2023a) Limits scale in large or dispersed systems. (UNESCO, 2023a)
Hybrid	<ul style="list-style-type: none"> Combines online flexibility with in-person interaction. (Frontiers in Education, 2025) Allows content adaptation to local contexts. (Villegas Reimers et al., 2023) Balances cost, reach, and engagement. (de la Puente Pacheco et al., 2024) 	<ul style="list-style-type: none"> Requires coordination between formats. (Global Partnership for Education, 2025) Generates logistical costs for in-person sessions. (Global Partnership for Education, 2025) Depends on consistent connectivity for online components. (Hennessy et al., 2022)

Source: Authors

For the purposes of the Digital Calculator, we consider these three reference scenarios: hybrid, online or in-person. This approach provides greater flexibility for implementation across different contexts and budget conditions.

2.3. Training Design

The teacher training design must ensure that educators can apply knowledge, skills and attitudes meaningfully in their classrooms (OECD, 2025). In this sense, training design must be practical. Content should allow educators to connect to real classroom scenarios and daily challenges with their students. This practical focus allows educators to immediately apply new digital skills and tools to their teaching practice, bridging the gap between theory and effective classroom implementation. Without this, skills learned in training risk being forgotten or deemed irrelevant, hindering the adoption of digital tools and ultimately failing to impact student learning.

Designing teacher training requires careful attention to two central variables: 1) the curriculum and content design, and 2) the Learning Management Systems (LMS), which is the digital infrastructure that supports delivery. These elements are essential for ensuring that training is aligned with teachers' needs. Together, they shape how teachers progress through tiered learning pathways.

2.3.1 Curriculum and Content Design

Once the training modality and tiered levels are defined, the focus shifts to designing the curriculum and creating the training content. This complex task must be guided by established competency frameworks and preliminary diagnostic results, which ensures that each teacher is placed on a development pathway suited to their current skills.

Ideally, the training content should be anchored to an established Competency Framework, like the IDB's EduTec Guide framework, the UNESCO's ICT Competency Framework for Teachers, or the the Digital Competence Framework for Educators (DigCompEdu), among others This structure is critical because competency-based teacher training goes beyond mere content delivery (OECD, 2025); instead, it emphasizes the educator's ability to mobilize knowledge, skills, and attitudes in an integrated fashion. Consequently, a digital competency framework is essential for clearly establishing the required digital skills and proficiencies for teachers. This clarity ensures that all professional development efforts are targeted, relevant, and directly contribute to the teacher's capacity to integrate technology effectively.

Building upon a competence framework, training content must clearly demonstrate not only what teachers need to learn but also how to apply these skills directly in the classroom. To achieve this essential practical focus, training materials should be designed to be interactive, adaptable, and specifically linked to real teaching scenarios, allowing educators to immediately put their learning into practice (OECD, 2025). This emphasis on practical application is required for effectively bridging the gap between theoretical knowledge and successful technology integration in daily teaching practice.

2.3.2 Learning Management Systems (LMS)

A robust LMS is the backbone of an efficient teacher training because it centralizes course organization, content distribution, and teacher–trainer interaction. It also tracks progress, provides data for monitoring, and enables scaling across geographically dispersed networks.

Key considerations for LMS implementation:

- **Licensing and technical support:** ongoing costs to maintain the platform and resolve technical issues.
- **Accessibility:** ensuring all teachers have reliable internet access and devices.
- **Integration with tiered pathways:** The LMS should allow teachers to follow their assigned level, access appropriate content and participate in interactive activities that reinforce learning.

For online or hybrid modalities, the LMS is critical to maintaining pedagogical effectiveness. It connects the practical, framework-aligned curriculum with teachers' day-to-day professional practice, enabling measurable learning outcomes. More details on LMS can be found in the next section.

3. Implementation: Trainers

For teacher training to achieve meaningful and lasting results, it must be supported by a **sustainable network of trainers**. These professionals are central to disseminating knowledge, methodologies, and digital technologies across schools, ensuring that professional development goes beyond isolated workshops and becomes part of daily pedagogical practice.

3.1 Recruiting and preparing Trainers

To be effective, trainers must master educational technologies, apply active learning methodologies and evaluate participant progress. In order to achieve this, two major cost variables must be considered when planning teacher training.

The **first** is ensuring sufficient coverage, which means having enough trainers to reach all teachers. In the calculator, we assume one trainer for every **50 teachers**, corresponding to training groups of **50 participants**. This structure reflects scalability and a flexible trainer-to-teacher ratio, which may vary depending on the delivery modality (Velooso & Mill, 2021). It also requires both financial investment and careful logistical planning to provide equitable access in urban and rural areas.

The **second** variable is **trainer preparation**. Even highly qualified professionals need training to implement the program effectively and stay up to date. In the calculator, this is modeled as courses for groups of 50 trainers, including workshops, specialized courses, or certification programs. While this adds to the budget, it is essential for maintaining consistency.

3.2 Other strategies to scale: the cascade model

When implementing teacher training, governments need to consider several key aspects. One of the most efficient approaches to scaling training is the **cascade model**, in which a core group of trainers or multipliers receives intensive preparation and then disseminates knowledge across schools. This structure promotes scalability, reduces costs and ensures that learning is progressively internalized within each context.

Research by OECD (2025) demonstrates that the most effective training combines multiple stages: theoretical input, modeling of practices, supervised application in real classrooms, and continuous feedback. Within cascade structures, **multipliers** are not mere content replicators—they provide ongoing pedagogical support, helping colleagues integrate new practices sustainably.

The **training of multipliers** has proven particularly popular in Latin America and the Caribbean, where large systems face the challenge of scale. Multipliers are

teachers recognized for their expertise, leadership, and commitment to innovation. After more advanced training, they return to their schools to mentor colleagues, fostering collaboration and promoting effective use of digital resources.

Notable initiatives illustrate this strategy:

- In São Paulo, the **Multiplica SP #Professores** program created a cascade structure in which specialists train educators, who then support peers both in-person and online.
- In Mato Grosso, the “Pacto pela Digitalização” (**Digitalization Pact**) combines cascade training with financial incentives, including scholarships and teaching-hour compensation, ensuring both engagement and sustainability (Fundação Telefônica Vivo, 2022).
- In Uruguay, **Ceibal** offers multiple training modalities, from online virtual courses to in-person strategies. The teaching training models have progressively come to include new topics such as leadership, socioemotional education, rethinking assessment (Villegas-Reimers et al., 2023).

By valuing peer mediation and local adaptation, cascade training transforms professional development into a **collaborative and contextualized process**, rather than a top-down intervention.

The multiplier structure was not included in the calculator’s budget, as we recognize that its adoption must be carefully tailored to the realities of each education system. Nevertheless, evidence from successful experiences suggests that this model can generate highly beneficial results.

3.3 Incentives and Sustainability

Valuing trainers and multipliers is essential to sustain professional development efforts. International research (Darling-Hammond, 2017) shows that **incentives** - such as scholarships, additional remuneration, or career recognition - significantly increase engagement and adoption of new practices.

Incentives linked to structured career progression act as both motivators and re-

tention mechanisms. They formally acknowledge the effort involved in training others and reinforce the central role of teachers as agents of change. As well, scholarships often offer a sustainable alternative by reducing labor charges and broadening reach (Darling-Hammond, 2017).

In contexts with budget constraints, other recognition mechanisms may be adopted, such as certification that contributes to career advancement. What matters is that incentives are systematically integrated into policy design, ensuring both continuity and impact.

It is important to highlight that, within the current cost calculation model, direct financial incentives for participating teachers are not foreseen; remuneration is limited to trainers. This approach reflects the need to balance program impact with available resources. It also recognizes that alternative forms of incentive and professional recognition may be adopted to encourage teacher engagement. Nonetheless, the adoption of incentives, whether financial or otherwise, should be considered, taking into consideration the context and budgetary possibilities.

Examples from international and regional practice illustrate different approaches. In 2022, Spain updated its National Reference Framework for the Digital Competence of Teachers, outlining six key competence areas and associated achievement indicators (Ministry of Education and Vocational Training Spain, 2022). This framework supports a national certification initiative targeting the assessment and accreditation of digital competencies for 80% of primary and secondary school teachers—around 700,000 educators—by 2024. Regional governments are responsible for implementing the certification process, which is backed by €284.7 million in central funding from the Ministry of Education and Vocational Training (European Commission, 2022).

Another example is the Pacto pela Digitalização, in Brazil, mentioned previously. This initiative was structured based on a diagnostic of teacher competencies, offering tiered learning pathways aligned with different proficiency profiles and including a policy of financial incentives. The program provides stipends for trainers and multipliers, ensuring teacher engagement and program sustainability (Fundação Telefônica Vivo, 2022).

4. Logistics and Infrastructure

The expanded use of digital technologies in everyday school life introduces new challenges to teacher training, particularly regarding the infrastructure and logistics required to ensure high-quality professional development processes. Within the context of public education in Latin America and the Caribbean, these challenges compound historical inequalities across education networks, necessitating educational policies that take into account the local specificities of each region. In this scenario, the costs associated with face-to-face training, including transportation, lodging, meals, and venue rental, become a strategic factor that must be reassessed in light of the opportunities offered by hybrid and online models.

A well-established example of efficiency in this regard is Uruguay's Plan Ceibal. The program offers a flexible and heterogeneous strategy for teacher professional development, combining in-person, virtual, and hybrid formats — including regional congresses held in different locations across the country and online courses available on demand. This approach allows greater numbers of teachers to participate without requiring additional in-person cohorts (Ceibal, 2024a). The strategy balances the human dimension of direct contact with resource rationalization, leveraging existing digital infrastructure to expand training reach (Villegas-Reimers et al., 2023).

In 2024, within the teacher training framework of Plan Ceibal, three courses focused on digital citizenship were developed on the EDUx platform. The courses were structured through an integrated approach involving multiple organizational departments, including Digital Citizenship and Wellbeing, Research, Development and Innovation, Computational Thinking and Artificial Intelligence, and Pedagogical Innovation (Ceibal, 2024b). Training pathways were also structured to support both initial teacher education and in-service teacher development (Ceibal, 2024a). Within this context, decision-support tools such as interactive Power BI dashboards accessible via mobile devices were developed, representing significant advances in the quality and accessibility of information (Ceibal, 2024a).

Observing teacher training experiences in Uruguay through Plan Ceibal, it becomes clear that another crucial factor is logistical adaptation to the local context.

Governments that utilize their own infrastructure, such as schools and training centers, avoid rental expenses, while those with local funding policies can cover part of transportation and accommodation costs. Furthermore, by organizing regional training with trainers traveling to various hubs rather than concentrating teachers in a single location, some institutions significantly reduce individual teacher costs.

Therefore, the logistical costing of teacher training should not be standardized but rather tailored to each context. After all, costs may vary considerably depending on:

- **Use of resources:** Many education systems have their own physical spaces for training, which reduces venue rental costs.
- **Local funding policies:** Some networks cover transportation and lodging through existing programs.
- **Geographic distribution of participants:** The logistical cost of in-person training is directly influenced by the distance between teachers and training sites. In geographically dispersed networks, expenses related to transportation, lodging, and meals can represent a significant portion of the training budget. A strategy to optimize these costs involves sending trainers to various regional hubs.

By considering variables such as diagnostic assessments, teaching modality, content, trainer development, and infrastructure, this framework enables education managers in Latin America to develop detailed budget projections, ensuring that investments in teacher training remain sustainable and effective over the long term.

In a context of scarce resources and urgent demands for innovation, structuring the logistics of teacher training based on technical criteria and cost-optimization strategies is a fundamental step to ensure that the digital transformation of education is not only feasible but also sustainable and equitable throughout the region.

Unlike other procurement items, logistical costs (such as trainer and teacher commuting, accommodation, and catering) are highly context-dependent and subject to significant regional variation. Itemizing these costs for a general calcu-

lator is therefore impractical. However, to provide policymakers with a necessary comparative benchmark—specifically to illustrate how much in-person training generally costs compared to online or hybrid models—the calculator incorporates estimates derived from standard procurement models. These estimates serve as a tool for understanding the relative financial implications of different training modalities, supporting informed resource allocation decisions.

5. Summary

Therefore, these are the items we are calculating within this dimension. The calculation for Training Design adapts based on the total number of hours (40 or 60), while the costs for Trainers and Trainer Courses also vary depending on the duration and also the chosen modality (online, hybrid, or in-person).

TABLE 12
Overview of the Teacher Training Dimension

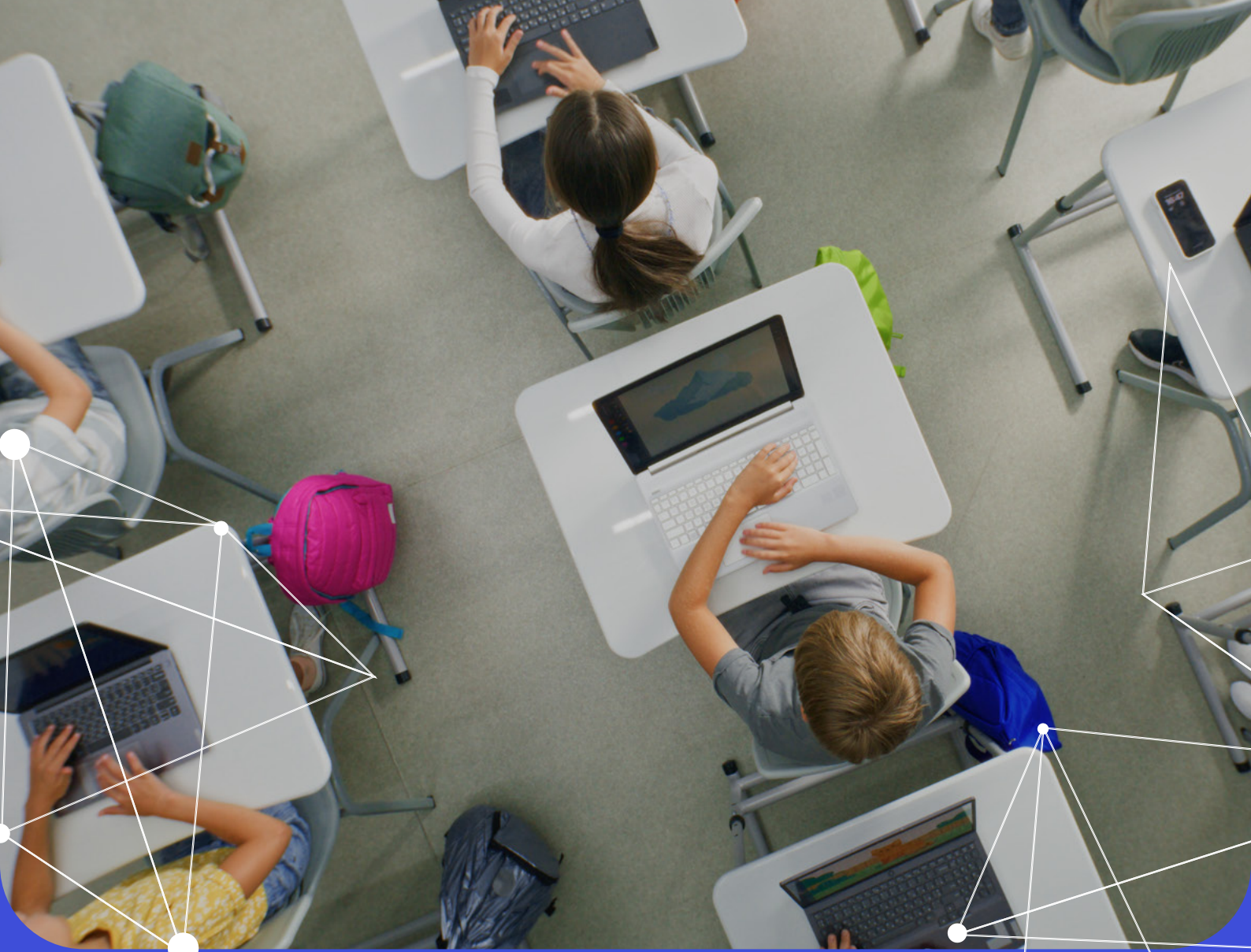
Subvariable	Parameter	Quantity	Assumptions
Diagnostic Tool	1 tool for all (independent of the amount of teachers)	-	Cost independent from the education data
Training Design	1 tool for all (independent of the amount of teachers)	-	Cost independent from the education data
LMS Platform	1 tool for all (independent of the amount of teachers)	-	Cost independent from the education data
Hiring Trainers	50 teacher per cohort	Number of teachers to be trained	-
Trainer Course (Training the trainers)	50 teacher per cohort	Number of trainers to be trained	The number of trainers is the number of teachers divided by 50, considered the 50-size cohort

Source: Authors

How does this dimension look in the Calculator?

The screenshot shows the 'Teacher training' section of the calculator. It includes a purple circular icon with a graduation cap and the text 'Teacher training'. Below the title, it says 'If you have more updated data available, you are welcome to edit the fields.' On the right, there is a text box explaining the dimension and its sub-dimensions, followed by a link for more information. A black box at the bottom right displays 'DIMENSION ESTIMATED COST' as '\$48.1mi'. At the bottom of the interface, there is a navigation bar with buttons for 'Setup', 'Teacher training', 'Previous', and 'Next'.

Source: <https://www.edudigitalcalculator.org>



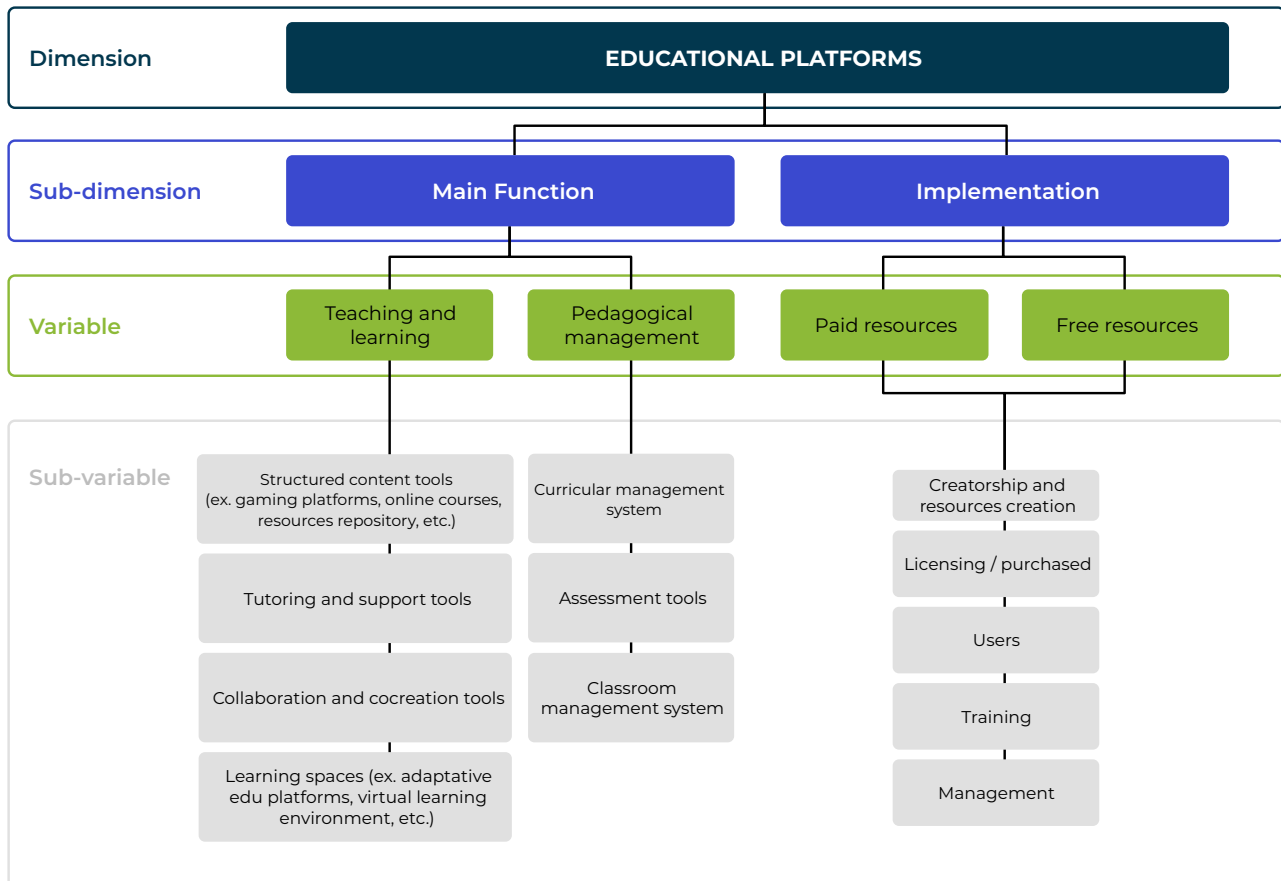
DIMENSION

4

Educational Platforms

With the proper implementation of the previous dimensions, a school is almost ready to fully integrate technology into daily routines - with the necessary infrastructure and trained staff. At this stage, attention turns to the platforms, programs, and software that run on school devices to support the full range of educational activities. This dimension focuses on these digital tools, referred to here as Educational Platforms.

Within this dimension are two sub-dimensions: Main Function and Implementation, as shown in the diagram below. The Main Function sub-dimension addresses the varied uses within schools — categorized as teaching and learning (including structured content tools, tutoring and student support tools, collaboration and co-creation tools, and learning spaces) and pedagogical management (including curricular management systems, assessment tools, and classroom management systems). The Implementation sub-dimension considers how platforms are made available, which involve curatorship and/or resource creation, licensing, purchasing, defining users, training, and management, for both free and paid resources.



Despite warranted concerns around the unintended impact of technology use on education (UNESCO, 2023a), digital technologies can greatly enhance both administrative and pedagogical school activities. The report highlights that digital educational platforms have dramatically increased access to teaching and learning resources worldwide—for example, benefiting students in remote areas or those with disabilities.

For instance, in China, recorded lessons shown on devices in classrooms reached more than 100 million rural students—boosting student performance by 32 % and reducing the urban-rural wage gap by 38 % (Bianchi et al., 2022). On the use of EdTech for inclusive education, a global survey found that computers, text-to-speech tech, braille writing devices, and other assistive technologies helped students access textbooks (26%), improve communication skills (25%), develop social skills (15%), and increase sign-language knowledge (10%) (World Bank, 2022). These are examples of digital educational platforms being used as Content or Tools for teaching and learning activities.

In Brazil, for example, there is a synchronous remote teaching and hybrid learning experience called the Media Centers that are providing remote synchronous education to regions in which building schools and hiring specialized teachers is particularly challenging (Arias Ortiz et al., 2020b). As well, in Honduras, the country is using asynchronous learning platforms such as Kolibri to reach students in remote communities (Innovations for Poverty Action [IPA], 2022).

According to the Brazilian Innovation Centre for Education (CIEB, 2021), Digital Educational Resources comprise digital content, tools, and/or platforms designed for educational purposes (pedagogical or administrative), intended to facilitate, enhance, and support the work of teachers, students, and administrators.

There is a vast selection of educational platforms available for schools, each addressing different needs, audiences, and formats. These can be purely digital content for student consumption, digital tools for pedagogical management or administration, or comprehensive platforms that address multiple functions in one system. Therefore, it is essential to thoroughly understand the context of schools or educational networks to ensure selected platforms align with identified educational needs.

To ensure digital platforms align with educational challenges and learning objectives, dialogue between educational authorities and schools is vital—creating forums for listening and validation so the chosen platforms genuinely serve institutional needs.

This section will present the different types of educational platforms available and best-practice strategies for effective implementation—emphasizing the importance of a strategic network-wide vision for integrating technology into curricula and pedagogical practices with intentionality and alignment with planning.

1. Platform Function

CIEB (2021) proposes a classification of different types of educational platforms, organizing them into macro-groups that represent the demands a given educational platform seeks to meet, or grouping software with similar characteristics (scope) divided into content, tools, and platforms.

This classification aims to facilitate education managers' evaluation process when selecting educational platforms suitable for their schools' context. The organization of demands ranges from activities related to the teaching and learning process related to pedagogical activities carried out by teachers and other education professionals. The proposed macro-groups will be presented in the following images, with eighteen different types of educational platforms grouped first by software characteristic (scope) and then by the type of demand they aim to address.

TABLE 13
Types of Platforms

Content	Tools	Platforms
1. Digital learning object (DLO)	4. Pedagogical management support tool	11. Classroom management system
2. Educational game	5. Student learning management tool	12. Virtual learning environment (VLE)
3. Online course	6. Curriculum management tool	13. Educational platform
	7. Authoring tool	14. Adaptive educational platform
	8. Classroom support tool	15. Online content delivery platform
	9. Collaboration tool	16. Digital repository
	10. Tutoring tool	

Source: adapted from CIEB (2021b)

“Content” is classified as media—interactive or not—created or used with an intentional pedagogical purpose. These are the smallest instructional units into which a larger educational platform can be decomposed.

Educational platforms classified as “Tools” are technologies that support a specific school process, optimizing or facilitating it, and may use or include associated content.

Lastly, the “Platforms” category groups the more robust educational platforms, characterized as articulated sets of tools arranged in a coordinated, robust structure. These are usually adopted transversally by schools and may include or use associated content and tools.

1.1.1. Educational Platforms for Teaching and Learning Processes

This section details all educational platforms types that comprise the categories Structured Content, Learning Spaces, and Authoring and Collaboration, which collectively address the Teaching and Learning demand — the most comprehensive of the three categories depicted in the diagram.

TABLE 14
Platforms for Teaching and Learning

Educational Platforms	Definition	Examples
Digital Learning Object (DLO)	Any ready-to-use digital content that can be embedded or integrated into various tools and platforms. This includes videos, images, texts, interactive content, quizzes, and more.	<ul style="list-style-type: none"> • A video lesson on fractions used by students for home study. • A podcast about colonial Brazil suggested as supplementary content for history classes. • An environmental news article used by a science teacher during class.
Educational Game	A gamified software designed or used for educational purposes to deepen knowledge and support student development. It can be embedded or integrated into multiple platforms.	<ul style="list-style-type: none"> • A 3D third-person game that allows students to explore a historical setting and interact with period characters. • A game that presents mathematical and computational logic problems in an engaging, playful format.
Online Course	A sequential set of digital learning objects organized within a virtual environment, enabling fully self-paced learning. May include videos, texts, assessments, discussion forums, and certification.	<ul style="list-style-type: none"> • An online coding course for youth, offering videos, assessments, and interactive games. • An online carpentry course combining instructional videos with practical exercises.
Authoring Tool	Enables users to create and edit digital content in various formats (texts, videos, images, games, simulations) without requiring advanced technical skills.	<ul style="list-style-type: none"> • Presentation software used by teachers in classrooms. • An app that allows students to program and develop their own educational games.
Classroom Support Tool	Assists teachers in planning and delivering in-person lessons. May include activity management, content sharing, and real-time interaction.	<ul style="list-style-type: none"> • An app that enables students to send questions to the teacher in real time during class. • A platform where teachers store teaching materials and track activities conducted in each lesson.

Digital Learning Cost Calculator

Educational Platforms	Definition	Examples
Collaboration Tool	Enables students and teachers to collaboratively work on projects and edit content in real time, whether remotely or in person.	<ul style="list-style-type: none">• An online text editor where students collaboratively write a literary essay.• A tool that allows teachers and students to share materials and make collaborative annotations.
Tutoring Tool	Facilitates interaction between tutors, teachers, and students remotely, providing individualized support and academic reinforcement via video, audio, or chat.	<ul style="list-style-type: none">• A software platform enabling teachers to provide online tutoring through video conferencing.• A virtual space where students can ask questions via chat and use an interactive whiteboard.
Virtual Learning Environment (VLE)	An online platform that supports the creation of remote or hybrid learning environments, offering content management, activities, assessments, and interaction between students and teachers.	<ul style="list-style-type: none">• A platform used in English classes offering structured activities and regular assessments.• A system that provides learning pathways organized by subjects and skills.
Educational Platform	Provides a structured set of content and activities aligned with a specific curriculum, facilitating sequential teaching and learning processes.	<ul style="list-style-type: none">• A system used in English classes, offering progressive activities and periodic assessments.• A platform with learning pathways organized by subjects and competencies.
Adaptive Learning Platform	Personalizes the learning experience by adjusting content and activities based on each student's performance and progress.	<ul style="list-style-type: none">• An app that suggests math exercises tailored to a student's specific difficulties.• A language learning platform that adapts its content according to the learner's progress.
Online Content Distribution Platform	Provides access to courses, games, and educational materials either for free, through one-time purchases, or via subscription.	<ul style="list-style-type: none">• A website selling individual online courses for students.• A subscription-based platform offering video lessons for exam preparation.
Digital Repository	Stores and organizes educational content, enabling users to search, access, and download materials for use in diverse teaching and learning contexts.	<ul style="list-style-type: none">• A website where teachers share lesson plans and educational resources.• A platform that hosts digital learning objects categorized by subject areas.

1.1.2. Educational Platforms for Pedagogical Management

The following educational platforms types are designed to support teachers and school administrators in the management of pedagogical activities.

TABLE 15
Platforms for Pedagogical Management

Educational Platforms	Definition	Examples
Pedagogical Management Support Tool	Organizes and facilitates pedagogical processes such as enrollment, lesson planning, grading, class records, and communication among teachers, students, and families.	<ul style="list-style-type: none"> • An app that sends students' grades directly to families via SMS. • A platform that allows teachers to digitally plan lessons and school calendars.
Student Assessment Tool	Enables the creation, administration, and monitoring of assessments. May include question banks, automatic grading, and performance reports.	<ul style="list-style-type: none"> • A website where teachers can create and automatically grade quizzes. • An app allowing students to answer questions in real time via their mobile devices, generating instant statistics for the teacher.
Curriculum Management Tool	Supports the organization and systematization of pedagogical practices, content, and skills, assisting in structuring and monitoring curriculum implementation.	<ul style="list-style-type: none"> • A website where administrators structure the school network's curriculum and teachers access it for lesson planning. • A software tool that maps the coverage of skills and competencies within school planning.
Classroom Management System	Allows teachers to monitor and control student device usage during class, facilitating the management of pedagogical activities.	<ul style="list-style-type: none"> • Software installed on school tablets that lets teachers view and control students' screens. • An app for distributing activities and tracking students' progress in real time.

1.1.3. Learning Management System

A Learning Management System (LMS) is a digital platform designed to organize, deliver, and monitor learning processes in schools, universities, and training institutions. It serves as a Virtual Learning Environment (VLE) that integrates different tools for content delivery, communication, assessment, and management.

It integrates many of the functions previously described so it becomes an interesting option for education systems to invest in an integral platform.

Examples of LMS that are used by schools in Latin America and Caribe are:

- **Moodle**
- **Google Classroom**
- **Microsoft Teams for Education**
- **Blackboard Learn**
- **Schoology**
- **Edmodo**

Here is a summary of the functions that an LMS covers:

TABLE 16
Learning Management Systems Overview

Category	Function	Covered by LMS?	Description
Structured Content	Digital Learning Object (DLO)	Yes	LMS allows uploading and reusing DLOs (SCORM, xAPI).
	Digital Repository	Partial	Basic repositories exist, but often complemented by external systems.
	Online Content Delivery Platform	Yes	Core LMS function: delivering structured content.
	Online Course	Yes	LMS are designed to host and manage online courses.
	Educational Game	Partial	Some LMS integrate gamification, but full game platforms are external.

Digital Learning Cost Calculator

Category	Function	Covered by LMS?	Description
Learning Spaces	Virtual Learning Environment (VLE)	Yes	An LMS itself is a VLE.
	Educational Platform	Yes	Centralized platform for learning and teaching.
	Adaptive Educational Platform	Limited	Some LMS support adaptive modules; usually external tools.
	Classroom Support Tool	Yes	Includes attendance, homework submission, grading, etc.
Authoring and Collaboration	Authoring Tool	Limited	Basic authoring included, stronger with external tools.
	Tutoring Tool	Partial	Discussion boards and video integration; human tutoring external.
	Classroom Support Tool	Yes	Assignments, forums, messaging, group work supported.
Pedagogical Management	Pedagogical Management Support Tool	Partial	Supports planning; SIS needed for full coverage.
	Curriculum Management Tool	Limited	Some alignment to standards; deeper mapping external.
	Classroom Management System	Yes	Includes attendance, communication, assignments, and grades.
	Student Learning Assessment Tool	Yes	Provides quizzes, rubrics, analytics, and gradebooks.

2. Implementation

Implementing digital educational platforms in public institutions represents one of the most complex challenges in advancing digital transformation in education. This process goes beyond the simple introduction of technology; it is a continuous cycle of adaptation, development, and evaluation, where technology must consistently serve pedagogical objectives and meet student needs (World Bank, 2022).

Selecting the appropriate platform—whether free, freemium, or paid—requires careful consideration. While more robust platforms may offer advanced functionalities, they do not automatically ensure greater pedagogical effectiveness. Conversely, free or freemium solutions must be rigorously assessed for compliance with data access, security, and privacy regulations, particularly in jurisdictions with strict legal requirements.

Once a platform is selected, successful implementation depends on meticulous planning to embed it within everyday school routines. This includes allocating financial and human resources, registering users, distributing licenses, and providing structured technical and pedagogical support alongside ongoing teacher training (CIEB, 2021).

In Latin America and the Caribbean, the primary challenges are not limited to acquiring technology but extend to its effective, sustainable, and contextually appropriate integration (UNESCO, 2023b; World Bank, 2022). Ensuring success requires careful procurement, targeted teacher training strategies, ongoing technical support, and monitoring the platform's impact on learning outcomes.

This chapter examines the critical elements involved in implementing digital platforms in public schools, including procurement strategies, decision-making processes, pedagogical integration, and day-to-day operational management. It also explores how different types of platforms can be leveraged to support teaching and learning while emphasizing the factors essential to ensuring that these technologies contribute to reducing educational inequalities and enhancing learning outcomes.

2.1 Acquisition of Digital Educational Platforms

As the EdTech market expands across Latin America and educational institutions advance in consolidating their technological infrastructure, a new strategic challenge emerges: the selection, procurement, and, most importantly, the effective implementation of digital educational platforms (CIEB, 2021; HolonIQ, 2024). This process involves more than acquiring software; it requires the intelligent integration of digital solutions that align with pedagogical practices, school management models, and administrative needs. It is a critical step to ensure that technology not only modernizes processes but also contributes meaningfully to improving education quality, personalizing learning, and strengthening educational governance.

In this context, educational institutions may opt to purchase licenses for a wide variety of digital educational platforms. These solutions include adaptive learning platforms, Learning Management Systems (LMS), digital libraries, gamification tools, and software for teaching programming, robotics, languages, socio-emotional skills, and formative and summative assessment solutions.

Thus, the acquisition process involves strategic decisions about the adoption, curation, production, and integration of digital technologies into pedagogical processes. Public and school administrators must consider both commercial and free solutions, evaluating not only costs but also pedagogical relevance, sustainability, and their impact on student learning.

These tools are essential to building more responsive, data-informed educational systems capable of personalizing teaching and learning processes (CIEB, 2021).

Moreover, the adoption of such solutions must be aligned with a clear and context-sensitive pedagogical project. Without this alignment, there is a risk that technologies may be underutilized or even reinforce existing educational inequalities, rather than promote innovation and inclusion (CIEB, 2021; UNESCO, 2023a).

For example, with the support of the IDB, Uruguay's Centro Ceibal advanced a large-scale program for acquiring and consolidating educational platforms. This initiative has been central to expanding access to digital tools for students and teachers, with a particular focus on computational thinking, STEM (Science, En-

gineering, Technology and Math) learning, and innovative pedagogies. The program financed the renewal of devices and also the strengthening of Ceibal's digital ecosystem, including platforms such as SEA for assessments, virtual learning environments for deep learning projects, and Ceilabs for maker-centered innovation. Ceibal's financial and operational reports further illustrate how platform acquisition was embedded in a broader strategy of sustainability and accountability. The institution mobilized national budget allocations, complemented with IDB financing, to secure technological infrastructure, teacher professional development, and the integration of specialized educational platforms across the system. (IDB, 2024).¹¹

In general, platforms offer not only structured content aligned with curricular guidelines but also associated services such as technical support, regular updates, analytics dashboards, and training for teachers and school administrators. This combination directly contributes to improving pedagogical processes and supports data-driven school management — a central element in the modernization of educational systems.

2.2. Open Digital Educational Platforms

In addition to the paid solutions that drive much of the EdTech market, there are examples in Latin America of free digital educational platforms that help schools address challenges related to access and equity. These initiatives offer content, video lessons, interactive exercises, and support materials at no cost, contributing to the democratization of access to educational technologies and quality learning. This model, also known as Open Educational Resources (OER), is particularly relevant in budget-constrained contexts, enabling technological innovation to reach more students and teachers (UNESCO, 2019).

A practical example of the impact of open resources in Brazil is the Conviva Educação platform. As a free management system, Conviva provides essential tools for municipal education departments, from annual planning and importing national census data (Educacenso) to student enrollment tracking and agreement management. Its reach is notable: by the end of 2019, 92% of Brazilian municipalities were registered, with thousands of local education offices accessing the platform monthly (Cisco Brasil Digital et al., 2021). This initiative illustrates how

¹¹ More information: <https://www.iadb.org/en/project/UR-L1169>

free platforms can modernize educational management and positively impact teaching and learning outcomes.

Beyond fully free platforms, some companies adopt a freemium model. In this arrangement, basic functionalities are offered at no cost, with the option to unlock additional features for a fee. This flexibility allows schools to experiment with and use part of a solution without straining their budgets, while also assessing the actual need for future investments to expand the tools' functionalities or reach (CIEB, 2021).

However, the true digital transformation in education goes beyond the mere availability of tools. It is essential to encourage teachers to create their own digital educational resources and/or adapt existing ones, such as OERs (UNESCO, 2019).

This ability to author and curate content empowers teachers, enabling them to personalize materials, create interactive activities, and integrate multimedia elements that are contextually relevant for their students and communities. Doing so requires the ongoing development of specific digital competencies so that educators are not only consumers but also producers and adaptors of learning content. Investing in teacher training to support the development and adaptation of digital platforms is a strategic move to ensure that public schools can offer richer learning experiences aligned with local realities—transforming teachers into central agents of pedagogical digital innovation (CIEB, 2021).

When teachers are empowered to create or adapt digital learning resources, they can better align content with local contexts and specific student needs. This process, however, demands the development of targeted digital skills, such as proficiency with video editing tools, interactive activity creation, and content curation (CIEB, 2021). Promoting this kind of continuous professional development reinforces teacher leadership in the digital transformation of public education.

2.3. The Decision-Making Journey for Selecting and Implementing Educational Platforms

Amid an ever-growing array of digital educational platforms, public administrators face a fundamental question: how can one determine the most appropriate platform for a given educational context? And once a platform is selected, how

can it be implemented efficiently across school systems—reaching administrators, teachers, students, and support staff alike?

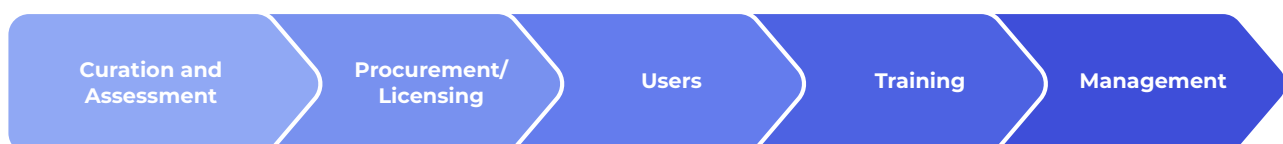
The choice is not simply a technological one. It is a strategic decision that must be aligned with pedagogical goals, the social and economic realities of each region in Latin America, and each country's commitment to providing inclusive, equitable, and high-quality public education.

To support this process, the selection and procurement journey for digital educational platforms has been structured into five major stages, based on a framework developed by CIEB (2021). This framework synthesizes best practices for effective procurement, drawing on international references that outline criteria for evaluating digital learning resources, financing digital initiatives, and assessing the impact of technology on learning.

Key references include guidelines such as the Selection of Learning Resources Directive (HWDSB, 2013) and the Educational Research Acquisition Consortium (ERAC, 2008), which present structured processes for selecting digital learning materials. Additional studies—such as those by Acree and Fox (2015) on state-level digital learning policies, and Anderson (2002) on networks of excellence in distance education—emphasize the importance of strategic planning grounded in international best practices.

Research by Cohen, Kalimi, and Nachmias (2013) contributes quality evaluation models for learning objects, offering valuable tools to build robust methodologies for selecting digital educational platforms.

The following sections summarize the key elements of each of the five essential steps for implementing digital educational platforms:



2.3.1. Curation and Assessment

The selection of an educational platform only makes sense when grounded in a deep understanding of the needs of the educational institution. Therefore, the starting point for this process is the curation and qualified assessment of demand, which involves listening to school leaders, teachers, students, and local communities, as well as mapping existing challenges, priorities, and conditions.

This diagnostic phase must take into account multiple dimensions: available technological infrastructure, student profiles, teachers' digital competencies, current pedagogical practices, and alignment with the curriculum. To ensure this complexity is addressed, it is recommended that a multidisciplinary team be appointed to form a Working Group responsible for platform curation, given the multifaceted nature of the selection process (CIEB, 2021).

Once the institution's core needs are identified, the next step is to assess the demand for digital resources across schools within a given region or education network. This stage involves defining a strategy for gathering demand, which can take two forms:

Centralized: where educational managers estimate demand centrally, based on their prior knowledge of the network and school contexts, without the need for direct consultation with each school.

Decentralized: where schools are consulted and actively participate in the demand assessment process, reducing the risk of misalignment between schools and the education department.

Following this mapping, assessing the platforms available on the market always focuses on criteria that go beyond cost, such as pedagogical quality, accessibility, data security, and contextual relevance.

It might be relevant to encourage government to develop, adapt, or complement their own digital educational solutions. Strengthening pedagogical and technological autonomy helps build more responsive ecosystems, tailored to local needs and less reliant on off-the-shelf solutions that may not reflect the realities of public schools.

2.3.2. Procurement and licensing Contracting

Once the platform is selected, the licensing or contracting process begins. At this stage, attention must be paid not only to operational issues but also to legal, pedagogical, and ethical safeguards associated with technology use.

This goes beyond simply formalizing a contract. It is crucial to ensure that contracts include clauses protecting data privacy, guaranteeing technical support, providing for regular updates, and ensuring interoperability with existing systems in the education network.

Free platforms also require careful analysis. Free access does not equate to zero cost. The price may lie in the users' data, exposure to advertising, or limited access to essential features (CIEB, 2021). For this reason, legal, pedagogical, and technical evaluations must be equally rigorous, regardless of the business model (CIEB, 2021).

2.3.3. Users

Once the platform is implemented, it must be properly configured to reflect its intended user base. This includes registering users with different profiles—students, teachers, school leaders, and other education professionals—ensuring that each group has access to the appropriate features for their role within the educational process. In some contexts, users may also include parents or guardians, depending on the platform's design (CIEB, 2021).

User management is not merely a technical task. It is a critical step to ensure smooth platform use, protection of sensitive data, and continuous updates—such as student enrollment changes, transfers, or staffing updates.

Platform selection and contracting should always account for the target audience. As discussed in the Demand subdimension, different types of platforms serve different purposes, and each resource may be tailored to a specific audience. In schools, users may include students, teachers, school staff (such as administrative personnel or coordinators), and parents or guardians, depending on the platform's design and intended use (CIEB, 2021).

2.3.4. Training

For the effective implementation and use of digital educational resources, school networks should carefully assess the training needs of all users—teachers, managers, students, and even parents or guardians. Depending on the platform’s complexity, the required training may range from brief tutorials in text or video format to more comprehensive training programs requiring greater time investment (CIEB, 2021).

End-user training is a critical component, as it directly affects the adoption of the digital resources. Based on the platform’s complexity, training may vary from simple instructional content to more structured, in-depth programs. A clear communication strategy and a technical support plan are also key to engaging users and ensuring timely problem resolution.

2.3.5. Management

The successful implementation of digital educational platforms relies heavily on structured management and efficient technical support. From the outset, it is essential to clearly define who will be responsible for overseeing the adopted solution. Operational aspects such as installation, initial setup, user registration, and access control must be well planned.

It is equally important to establish how ongoing support will be provided to schools, the expected response times for issue resolution (SLAs), and the procedures for system maintenance and updates. These elements should be addressed during the platform selection process to avoid implementation bottlenecks that could undermine its effectiveness (CIEB, 2021).

For example, in Uruguay, Ceibal’s strategy has been the systematic monitoring of usage and learning outcomes of their platforms. Ceibal integrated monitoring mechanisms directly into its platforms, particularly through the SEA system, which enabled the calibration and application of computational thinking assessments. Indicators such as gender and socioeconomic gaps in learning, the number of students engaging in remote classes, and teacher participation in continuous training were regularly tracked and tied to program milestones. This results-based financing approach ensured that investments in platforms were

continuously evaluated against concrete evidence of student progress, institutional adoption, and teacher professional development, strengthening the credibility and sustainability of the program. (IDB, 2024)

Ceibal also established robust financial and technical accountability processes to complement the educational monitoring system. Annual audits and expenditure reviews verified that investments in devices, digital content, and socio-educational programs were aligned with declared outputs, while impact evaluations measured how platforms contributed to reducing learning gaps and fostering innovation in classrooms. Ceibal's monitoring framework combined quantitative data (such as platform log-ins, device usage, and course completion rates) with diagnostic tools like school self-evaluations and behavioral science pilots, offering a comprehensive picture of both usage and pedagogical impact. This integration of monitoring at multiple levels not only guided timely adjustments to platform implementation but also provided valuable lessons for the region on how to link technology acquisition with sustained improvements in equity and learning quality. (IDB, 2024)

Hence, management does not end with deployment. Once the platform is operational, it is important to monitor both its usage and its results. This requires the definition of clear indicators to track metrics such as the number of registered users, frequency of access, navigation time, and broader outcomes like improvements in student performance or school process efficiency.

Key questions include: How will the installation, setup, and user registration be carried out? What is the strategy for user support and system maintenance? What SLAs will be respected? What is the expected impact? These considerations must guide the platform selection and monitoring process (CIEB, 2021).

Tools such as dashboards, executive reports, and interactive data panels are valuable allies in this process, making information accessible and easy to interpret. Additionally, feedback from teachers, school leaders, and students is essential—not only to assess the platform's technical performance but also its alignment with pedagogical practices and local needs.

Finally, schools must establish from the outset clear criteria for which indicators will be monitored and for what purposes. This helps ensure that impact evalua-

tion is not limited to metrics provided by the platform itself, but rather aimed at answering the central question: Is the platform truly helping to address the educational challenges that motivated its adoption.

2. Summary

Therefore, this is variable the calculator considers for this dimension:

TABLE 17
Overview of the Platform Dimension

Subvariable	Parameter	Quantity
Teaching and Learning Platform	1 license per student	Number of Students

How does this dimension look in the Calculator?

The screenshot shows the 'Educational platforms' dimension in the calculator. It includes a sub-variable icon, a description of the dimension, and a table for 'Educational platform costs'. The estimated cost is \$295.5m.

Includes two sub-dimensions: Platform Function and Implementation Mode.

Platform Function covers Teaching and Learning, Pedagogical Management, and Administrative Activities. Implementation covers curatorship, licensing, user management, training, and management, not all elements generate direct costs.

[Check here for more information about sources and methodology](#)

Educational platforms

If you have more updated data available, you are welcome to edit the fields.

DIMENSION ESTIMATED COST \$295.5m

Educational platform costs

Educational platforms are digital tools designed to support and enhance teaching, learning, and overall schools management.

Setup | Educational platforms | Previous | Next

Source: <https://www.edudigitalcalculator.org>



DIMENSION

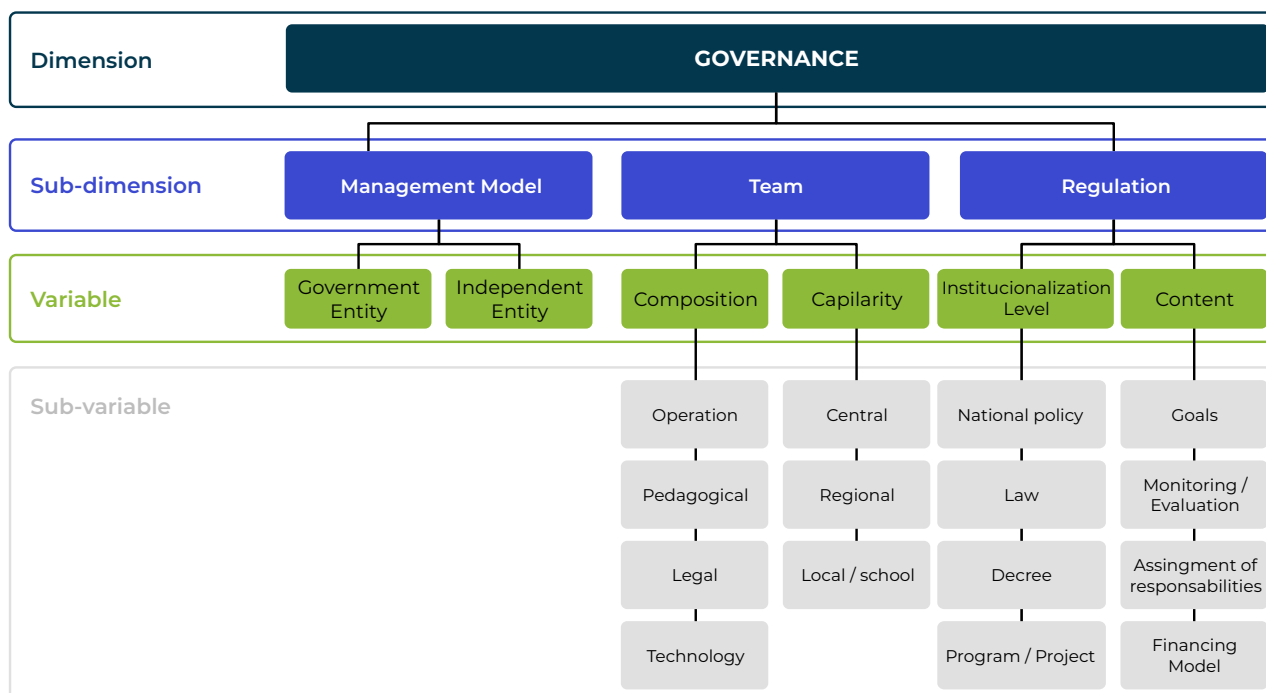
5

Governance

The digital transformation of public education is not only a matter of technological infrastructure—it is, above all, a matter of governance. Governance refers to institutional arrangements capable of coordinating public and private actors, setting priorities, and ensuring the long-term sustainability of educational policies (Kennisset, 2013; 2015).

In contexts of historical inequality and administrative fragmentation—as is often the case in Latin America and the Caribbean—strong governance structures become even more critical to ensure that digital innovations do not exacerbate disparities, but rather serve as tools for equity.

In this dimension, we examine how different governance models have been implemented in LAC countries such as Brazil, Mexico, Chile, Argentina, Uruguay, and Costa Rica. The following sections explore Brazil’s Connected Education Innovation Program (PIEC), “Computadores para Educar” in Colombia, “Enlaces” in Chile, and Argentina’s “Conectar Igualdad” Program. We also examine the role of independent organizations like Plan Ceibal and Fundación Omar Dengo, which have been instrumental in building innovative and sustainable digital education ecosystems for the long term.



1. Management Model

Management models are essential to ensure that resources are used efficiently and that actions are aligned with pedagogical objectives and the demands of educational institutions. In this context, a governance model refers to the definition of structures, responsibilities, and institutional mechanisms that organize how connectivity and digitalization policies are planned, executed, monitored, and improved.

In LAC, two main governance models have been adopted: one led directly by governmental entities, which centralize the coordination and implementation of policies; and another based on third-party entities, involving civil society organizations and other specialized institutions in the deployment of digital solutions in public schools. Below, we outline the features, advantages, and challenges of each model, along with practical examples from across the region.

1.1 Ministry-led Model

In this governance model, the coordination of digital education policy is carried out directly by a government body, such as a ministry or department of education. This ensures alignment with formal public policies and direct access to public resources. In Brazil, the Programa de Inovação e Educação Conectada (PIEC), launched in 2017 by the Ministry of Education, marked a milestone in bridging technology and public education policy¹².

Building on this foundation, the National Strategy for Connected Schools (Estratégia Nacional de Escolas Conectadas – ENEC), established in 2023, the National Strategy for Connected Schools in Brazil (Estratégia Nacional de Escolas Conectadas – ENEC), which was designed to ensure meaningful connectivity for 100% of Brazil's public schools. Coordinated by the Ministry of Education (MEC) in collaboration with other government agencies, the initiative promotes governance across policies and programs to ensure schools have access to digital infrastructure for learning. The strategy established a federative governance model involving the federal government, states, and municipalities. ENEC is structured around six thematic pillars: (i) Connectivity, (ii) Devices and Learning Environ-

¹² PIEC is a Brazilian public policy aimed at supporting the universalization of high-speed internet access and fostering the pedagogical use of digital technologies in basic education schools

ments, (iii) Curriculum, (iv) Competencies and Teacher Training, (v) Management and Digital Transformation, and (vi) Digital Educational Resources (ENEC, 2024).

Other Latin American countries have also advanced similar policies. In Chile, the “Enlaces” program, launched in the 1990s, was a pioneer in establishing inter-institutional governance to develop and support schools with technological infrastructure, technical assistance networks and digital content (Hinostroza et al., 2011). In 2018, **Enlaces evolved into the Centro de Innovación**¹³, expanding its scope beyond digital technologies to promote innovation in broader educational contexts. Building on the institutional foundation of Enlaces, the new center works with a wider audience, from early childhood to higher education, encouraging educational communities to design innovations tailored to students’ individual needs. Its purpose is to inspire schools to create learning experiences that foster active, critical, and responsible citizens, prepared to meet the challenges of the 21st century (Mineduc, 2025).

In Colombia, **Computadores para Educar (CPE)** represents a distinctive inter-institutional model for advancing digital inclusion in education. Established as an autonomous program governed by an association of public entities — including the Presidency of the Republic, the Ministry of Information and Communication Technologies, the Ministry of Education, the ICT Fund, and the National Training Service (SENA) — CPE promotes educational innovation through the access, use, and appropriation of digital technologies across schools nationwide. Its work is structured around four strategic axes: ICT access, pedagogical appropriation, environmental sustainability, and monitoring and evaluation (Computadores para Educar, 2025).

In Mexico, the governance of digital transformation in education has been structured through the Digital Education Agenda, launched in 2019 by the National Secretary of Public Education (SEP). The Mexican project has entered a new phase with the launch of **Inspira y Aprende**¹⁴, an integrated national strategy led by the SEP. The initiative renews the country’s digital education ecosystem by combining technological resources, multimedia content, and community partic-

¹³ Learn more about the project: <https://www.innovacion.mineduc.cl/inicio>

¹⁴ The project expands access to educational resources through multiple platforms, including the Aprende+ television channel and an online learning hub offering free courses and training programs for students and teachers. Learn more about the project: <https://www.gob.mx/sep/prensa/boletin-236-anuncia-mario-delgado-carrillo-renovacion-y-fortalecimiento-de-prende-mx-con-estrategia-integral-inspira-y-aprende>

ipation to promote continuous and inclusive learning (SEP, 2025).

These initiatives share a key feature: a government-led structure that connects various levels and sectors to ensure that digital transformation is an integral and lasting component of consistent public education policy.

1.2 Autonomous government entity-led model

In this model, policy management and implementation are carried out by non-governmental organizations or autonomous institutions that operate under contract or partnership with the government. This model allows for greater operational flexibility and often enables more rapid innovation but requires strong institutional coordination.

In Uruguay, Plan Ceibal has become one of the most successful examples of digital transformation in public education. Created in 2007 as a response to the global One Laptop per Child (OLPC) initiative, Ceibal quickly moved beyond device distribution to establish a state-led platform for digital educational services.

Unlike other regional initiatives, Ceibal was conceived as an autonomous agency, independent from the National Administration of Public Education (ANEP), granting it budgetary independence, administrative flexibility, and the ability to respond quickly to educational demands (Zucchetti et al., 2020). This institutional design enables Ceibal to operate not only in providing equipment and infrastructure but also in continuously developing the pedagogical and digital capacities of the school community through close coordination between central, regional, and local levels (Plan Ceibal, 2024).

With its own governance structure, Plan Ceibal operates with agility and autonomy, forging strategic partnerships and developing innovative solutions that include virtual learning environments, videoconferencing networks, artificial intelligence for personalized learning, and teacher training (Plan Ceibal, 2024). During the COVID-19 pandemic, its robust infrastructure enabled the continuity of remote education with high levels of student engagement, demonstrating the maturity of its implementation model (Trucco & Palma, 2020).

2. Multidisciplinary Teams

The formation of multidisciplinary teams stands as a cornerstone for the success of digital transformation policies in education. The complexity inherent in such initiatives requires more than just technology experts; it demands integrated governance composed of complementary skill sets capable of addressing the multiple dimensions of the educational ecosystem. The management team serves as the backbone of the policy, with its composition directly influencing both the trajectory and outcomes of implementation.

Global best practices consistently demonstrate that, without a well-prepared team, even the most promising projects remain confined to plans and reports. Countries such as Uruguay, Colombia, Brazil, Mexico, Chile, and Argentina have shown that achieving consistent, high-quality implementation at the school level is only possible when investments are made in decentralized, multifunctional teams. This section explores two fundamental components of such a structure: composition and capillarity.

2.1. Composition

The optimal composition of a governance team for digital education policies must reflect the inherent complexity of the sector. Diverse perspectives, drawn from various fields, are essential to ensure that planning is robust, implementation is feasible, and outcomes are pedagogically meaningful. There are four core profiles that are indispensable:

- **Pedagogical Profile:** Experts in curriculum development, teacher training, and instructional methodologies, ensuring that technology aligns with educational practices and learning goals.
- **Technological Profile:** Technicians and engineers specialized in infrastructure, cybersecurity, connectivity, support, and the development of educational digital solutions.
- **Legal Profile:** Legal advisors who ensure compliance with regulations, particularly regarding public procurement, data governance, and technological acquisitions.
- **Operational Profile:** Professionals responsible for the logistical execution of activities, including equipment distribution, delivery schedules, contracts, and vendor management.

When effectively integrated, these areas of expertise transform policies into coherent and actionable strategies that resonate with administrators, teachers, and students alike. Brazil's ENEC (National Strategy for Connected Schools) exemplifies this approach. Its Executive Committee brings together representatives from ten public entities spanning distinct areas of expertise — including the Ministry of Education (pedagogical), the Ministry of Communications and Anatel (technological and regulatory), the Casa Civil (political coordination), the FNDE and BNDES (operational and financial), and the National Research and Education Network — establishing a governance model that integrates complementary profiles to support state and municipal education networks in deploying contextualized digital solutions (ENEC, 2024).

In Uruguay, *Ceibal* stands out for its deep integration between the pedagogical and technological domains. Its teams not only deliver equipment but also collaborate closely with schools to foster a robust and lasting digital culture (Ceibal, 2024a). This combination of expertise is what differentiates transformative public policies from isolated, short-term projects.

2.2. Capillarity

The effectiveness of governance in digital education policies is intrinsically linked to the capillarity of the management team—that is, its ability to operate across the various administrative levels where policies are designed and implemented, thereby reaching an increasingly broad population. Structurally, capillarity is organized across three interrelated levels:

- **Central Level:** Responsible for formulating general guidelines and strategic planning. This level typically consists of specialized teams of six to eleven professionals. An example of this level is Peru's National Policy of Digital Transformation
- **Regional Level:** Functions as the bridge between the central and local levels, providing support and adapting actions to regional and contextual specificities. An example of this level are the Regional Directions of Education (DREs) that supervise and guarantee the education service in each of the 26 regions of Peru.
- **Local Level:** This is where policy is concretely enacted. Personnel monitors and supports implementation at the schools, ensuring alignment between

policy directives and the practical needs of schools. An example of this level are the Units of Local Management of Education (UGELs) that are decentralized units that supervise and manage a number of schools in a province or district.

Based on the levels outlined above, the Calculator proposes the following parameters, drawn from policies and initiatives across Latin America and the Caribbean (LAC) analyzed in this document:

TABLE 18
Governance Levels

Level	Description	Parameters	Main Function
Central Level	Defines guidelines and strategically plans the national digital education policy.	A team of at least six to eleven professionals, based on the number of thematic areas/sectors. Examples: EACE in Brazil.	Define policies, coordinate the program, and ensure overall alignment.
Regional Level	Connects the central level with local networks, adapting actions to local specificities.	One coordinator for every 50 schools.	Monitor monthly the implementation at the regional-level. Work closely with principals to ensure proper implementation.
Local Level	Implements and monitors the policy at the school level, with a focus on direct pedagogical support.	One professional for every 5 urban schools and one every 3 rural schools, ensuring ongoing pedagogical support.	Support weekly the implementation of the pedagogical innovations, working closely with teachers.

Source: Authors

In Brazil, the PIEC relies on a tiered articulation approach to scale support across the country. Federal-level coordinators train state coordinators, who in turn guide local articulators to support schools in developing technology plans and monitoring the use of digital resources. This structure allows the program to reach a large number of schools without requiring direct intervention from the federal level at each institution (MEC, n.d.).

These examples collectively underscore that the capillarity of the governance team is a decisive factor for the success of public policies. It ensures a continuous

flow of information and maintains an ongoing dialogue between decision-making and operational levels. Where this articulation is absent, the transformative potential of digital education policies is significantly undermined.

3. Regulation

3.1. Level of Institutionalization

The integration of digital technologies into public education requires a solid foundation of legal and administrative frameworks. Policies, laws, decrees and programs are essential to ensure the continuity, stability, and institutionalization of these initiatives. Across several countries in Latin America and the Caribbean, significant progress has been made in formalizing such instruments, allowing the digital transformation of public education to be treated as a state policy rather than merely a government initiative.

Below are representative examples from Latin American countries, illustrating how they are structuring the digital transformation of their education systems based on robust institutional frameworks.

Law

Law is the highest legal instrument within a country's legal framework, approved by the Legislative Branch and enacted by the Executive. In the context of digital transformation in education, legislation ensures stability, continuity, and legal legitimacy for public policies, regardless of changes in government. It establishes obligations, rights, and duties, while also securing funding sources and implementation criteria.

Uruguay is a notable example of this level of institutionalization. The Ceibal program was formally created by Presidential Decree N° 144/007 of April 18, 2007, with the objective of providing every public school student and teacher with a laptop, internet access, and digital training (Uruguay, 2007). The following year, the General Education Law No. 18.437 of 2008 elevated this commitment to the level of state policy, explicitly recognizing universal access to ICTs as a right of students and a duty of the State (Uruguay, 2008). The program's institutionalization was further consolidated through Law N° 18.640 of 2010, which created the

Centro para la Inclusión Tecnológica y Social (CITS) to manage the program, and the National Budget Law N° 18.719 of 2010, which established specific financial allocations and governance structures ensuring its continuity and long-term investment (Uruguay, 2010a; Uruguay, 2010b). Internationally recognized as a model for digital inclusion in public education, Ceibal demonstrates how combining a clear legal mandate with dedicated and stable financing can sustain large-scale educational transformation over time.

In Brazil, legislation was used to establish the National Digital Education Policy (Política Nacional de Educação Digital – PNED), enacted in 2023, which clearly exemplifies the role of law as a guiding instrument. Structured around four pillars — digital inclusion of the population, digital education for students and teachers, digital skills for the workforce, and incentives for research, development, and technological innovation — the PNED provides a strategic foundation for coordinated action across federal entities. Its role is essential to ensure that investments in connectivity, teacher training, digital resource development, and digital culture are planned in an integrated, systemic, and long-term manner (Brasil, 2023).

Decree

A decree is a normative act issued by the executive branch, designed to regulate and detail the implementation of laws or public policies. In practice, it operationalizes general guidelines, establishes technical standards, defines governance mechanisms, allocates institutional responsibilities, and can enable the immediate launch of initiatives.

In Argentina, Decree No. 459/2010 served as the legal instrument that formally established the Conectar Igualdad Program, one of the region’s largest digital inclusion initiatives. However, the program has undergone significant transformations in recent years. Although it was never formally terminated, it has been effectively paralyzed. In 2025, the Argentine government restructured its administration, transferring the program from the Ministry of Education to the state-owned company EDUC.AR S.A.U. under Decree 289/2025, with the stated goal of improving efficiency (Government of Argentina, 2025). Nevertheless, this shift coincided with severe budget cuts. Official data indicate that in 2024 alone, program execution declined by nearly 80%, leaving more than 3,170 public schools without adequate connectivity (Infobae, 2024).

Program/Project

Programs (or projects) represent the concrete implementation of the guidelines established by policies, laws, and decrees. They encompass practical actions, investments, timelines, and monitoring and evaluation indicators. In most cases, programs are responsible for the direct implementation of initiatives at national, regional, or local levels.

In Chile, the Enlaces program is an emblematic example. Established in the 1990s, it has become one of the most influential public policies driving the digital transformation of Chilean education. Enlaces integrates initiatives to strengthen technological infrastructure, develop digital content and resources, provide continuous teacher training, and conduct systematic monitoring through indicators such as the School Digital Development Index (IDDE).

3.2. Content

The impact of digitalization policies in public education is directly linked to the clarity and coherence of their content. This set of guidelines defines the direction, priorities, and long-term commitments for incorporating digital technologies into educational environments.

This content is structured around four key pillars: (1) clear objectives and targets; (2) robust monitoring and evaluation mechanisms; (3) a sustainable financing model; and (4) clear allocation of responsibilities among different levels of government and other stakeholders.

These elements not only guide policy implementation but also ensure their continuity, effectiveness, and capacity to drive meaningful transformation in schools. The following section analyzes how these four pillars are reflected in educational connectivity policies across Latin America.

- **Objectives**

Objectives serve as the starting point for transformation. They define not only what is to be achieved but also the expected changes within educational environments. In Brazil, for example, the National Strategy for Connected Schools (ENEC) aims to deliver high-quality internet to all public schools by 2026. The strategy

prioritizes schools in situations of greater social and geographical vulnerability, such as rural areas, Indigenous territories, quilombola communities, and urban peripheries (Government of Brazil, 2023).

In Uruguay, Plan Ceibal's goals go beyond providing devices and connectivity. Its objective is to foster digital inclusion, reduce inequalities, and enhance teaching and learning processes (Plan Ceibal, 2024).

- **Monitoring and Evaluation**

Latin America offers several examples of tools and processes for monitoring and evaluation that assess both the expansion of technological infrastructure and its pedagogical impacts.

Chile stands out for adopting the School Digital Development Index (Encuesta Nacional de Desarrollo Digital Escolar e Innovación Educativa – ENDDEIE), developed by the Centro de Innovación of the Ministry of Education in partnership with the Instituto de Informática Educativa of the Universidad de La Frontera. This tool measures not only technological infrastructure but also the development of digital competencies, the management of pedagogical innovation, and the effective use of ICT in schools. The ENDDEIE informs both funding decisions and pedagogical interventions nationwide (Centro de Innovación Mineduc, 2023).

Uruguay maintains a highly transparent and structured model. Plan Ceibal conducts continuous monitoring, publicly providing data on access, device usage frequency, use of educational platforms, and student performance impacts, along with periodic reports that support both management and public accountability (Plan Ceibal, 2024).

In Brazil, ENEC has established a monitoring system based on indicators such as connectivity coverage, internet quality, internal network availability, the number of schools served, and the pedagogical use of technology. Oversight is conducted by the Executive Committee, which relies on data from the School Census, reports from telecom providers, and pedagogical assessments (Government of Brazil, 2023).

- **Allocation of Responsibilities**

Clear definitions of the roles of different levels of government and institutional

stakeholders are crucial for the effectiveness of these policies.

In Brazil, governance of the National Strategy for Connected Schools is shared among the Ministry of Education (MEC), the Ministry of Communications (MCom), the National Telecommunications Agency (Anatel) EACE, and state and municipal education departments. The federal government acts as the coordinator, setting general guidelines, providing partial funding, and overseeing monitoring systems, while subnational entities are responsible for local implementation, maintenance of internal infrastructure, and professional development (Government of Brazil, 2023).

In Chile, coordination is centralized under the Innovation Center of the Ministry of Education, which leads the design, implementation, monitoring, and evaluation of digital policies. Local implementation involves municipal administrations and schools, particularly in teacher training and infrastructure management (Centro de Innovación Mineduc, 2023).

- **Financing Model**

Financing is a critical factor for the sustainability of these policies. Across the four countries analyzed, a mix of public funds, sectoral funds, and, in some cases, partnerships with the private sector is observed.

In Brazil, funding for ENEC is structured through multiple sources, including the Connected Learning Program and the Universal Telecommunications Services Fund (FUST). The model prioritizes schools with higher levels of social vulnerability, using technical distribution criteria such as lack of previous connectivity, rural location, and presence in traditional communities (Ministry of Communications, 2023).

Uruguay employs a centralized and sustainable financing model based on the national budget, with specific allocations approved annually in the national budget law. This ensures the maintenance of infrastructure, regular equipment upgrades, continuous teacher training, and the development of educational platforms (Plan Ceibal, 2024).

Chile finances its actions through the national budget, supported by the Public Education Support Fund (FAEP) and specific programs from the Ministry of Ed-

education (Mineduc). The distribution of resources combines technical criteria with equity principles, prioritizing schools facing the greatest challenges in infrastructure and digital inclusion (Ministry of Education of Chile, 2023).

In conclusion, while the institutionalization, monitoring, goal-setting, and financing models for digital education policies will necessarily vary across countries, one principle remains universally true: a robust policy must be comprehensive and address every critical aspect of implementation. Failing to establish a clear financing structure, for example, is a deficiency that can undermine the policy’s sustainability in the long term, regardless of how well other elements (like curriculum or technology procurement) are designed. Effective policy formulation, therefore, requires systemic coherence—where weaknesses in one area do not compromise progress achieved in others—to ensure that the initiative can endure and deliver consistent, positive impact over time.

4. Summary

In the calculator, the cost of the Governance dimension is composed by the following items:

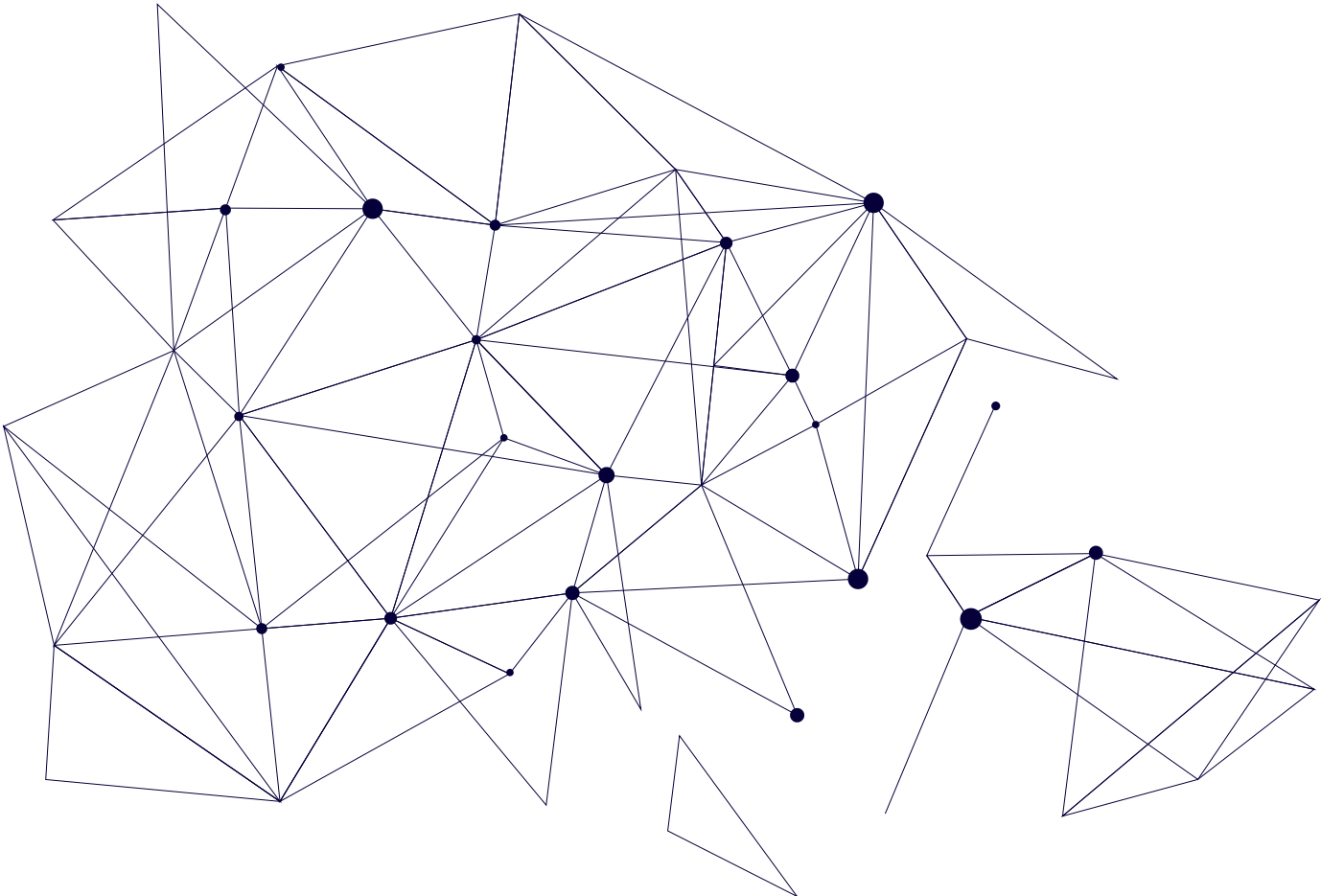
TABLE 19
Overview of the Governance Dimension

Subvariable	Parameter	Quantity	Assumptions
Central Team	6 - 11 people in the central team	-	Cost independent from the education data
Regional Team	1 individual per 50 schools	Number of Schools	
Local Team	1 individual per 5 urban schools 1 individual per 3 rural schools	Number of Rural schools Number of Urban Schools	

How does this dimension look in the Calculator?

The screenshot displays the 'Governance' section of the calculator. At the top left is a green circular icon with a white 'G'. The main heading is 'Governance' in a large, bold font. Below it, a sub-heading reads 'Governance Team'. A text box explains that the success of digital learning initiatives depends on a robust governance structure. To the right, a section titled 'Average salary for central team' displays '\$ 5,300'. At the top right, a summary box states 'DIMENSION ESTIMATED COST \$786.8mi'. A navigation bar at the bottom includes buttons for 'Setup', 'Governance' (highlighted in green), 'Previous', and 'Generate results'.

Source: <https://www.edudigitalcalculator.org>





Costs Estimations



1. Analytical Framework

This chapter presents the methodological framework that underpins the Digital Learning Cost Calculator. The Calculator has been conceived as a dynamic analytical tool that can be continuously refined as new data sources, technologies and policy contexts become available. Its purpose is to provide a transparent and adaptable structure for estimating the total cost of implementing digital learning initiatives at the system level.

The cost estimation methodology is grounded in the interaction of three components: quantity, technical parameters, and market prices (Annex E).

- The **quantity** component captures the scale of beneficiaries under consideration, such as the total number of students, schools, or teachers.
- The **market** price component represents the unit cost of each input, derived from local procurement data, supplier quotations, or benchmark price databases.
- The **technical parameters** component defines the operational standards or ratios that determine resource requirements, for example, the number of devices per student or the bandwidth required per school.

For each item, the total cost is calculated as the product of three components: quantity, technical parameters, and price. For example, when estimating the cost of tablets, the Calculator considers the number of students in the system, the number of tablets required per student, and the prevailing market price of each device. This same structure is applied across all five dimensions of the model, ensuring methodological coherence and comparability across cost categories. By linking quantitative scope, defined technical parameters, and market prices, the Calculator translates data inputs into transparent and replicable cost estimates. The platform also stores the underlying datasets, reference years, and sources used in each calculation, allowing results to remain traceable and verifiable while enabling future updates as prices, technical standards, and demographic information evolve.

The estimates generated by the Calculator are **preliminary**, representing cost approximations derived from the best available data. They are not intended to serve as finalized budgets, but rather as reference points to inform and guide policy

dialogue. The methodology follows a **zero-based costing approach**, which assumes no pre-existing infrastructure and thereby highlights investment needs and financing gaps. This approach supports governments in identifying priority interventions and sequencing investments in a transparent and evidence-based manner. The results should therefore be interpreted as inputs for strategic decision-making and as a foundation for more detailed assessments in subsequent stages of digital education planning.

Important Considerations

Timeframe

To ensure comparability between capital and operational expenditures, and to allow for consistent financial projections over time, all operational costs were calculated over a four-year (48-month) period. This timeframe was selected based on international examples of digital education investment planning and reflects the average depreciation cycle of most publicly procured equipment. The specification of which variables are considered capital (CAPEX) and which are operational expenditures (OPEX) is detailed on Appendix A.

Items categorized as CAPEX represent one-time investments with a defined useful life—such as computers, servers, cables, routers, or technical furniture. These assets become part of a school's infrastructure and remain in use until they are replaced due to obsolescence or wear. OPEX items, on the other hand, refer to recurring expenses, typically monthly, such as connectivity services, equipment maintenance, platform licensing, or technical support. Overall, most items assessed in this tool fall under the CAPEX category, underscoring the importance of a strong upfront investment that has a lasting impact on school operations. Nonetheless, the governance dimension, for example, is mainly from items classified as operational expenditures, as they represent the salary of the team responsible for the policy planning and implementation.

It is important to emphasize, however, that the values presented in the Calculator are not intended to serve as formal references for procurement or bidding processes. Rather, they are indicative estimates designed to support policymakers in understanding needs, defining key components and planning for technology-mediated education policies. These estimates provide a foundational layer for

the design phase and should be followed by more detailed technical planning and context-specific budgeting as part of the broader public policy cycle.

About the quantity

For each cost item, the quantity varies depending on its target group or unit of measurement. For example, when estimating the cost of teacher laptops, the relevant quantity is the total number of teachers, while for connectivity services the quantity corresponds to the number of schools. This flexible structure allows the Calculator to adapt to different policy scenarios, ensuring that cost estimates accurately reflect the operational scale of each intervention.

The Calculator obtains these quantities directly from educational data available through the [IDB CIMA Educational Statistics Portal](#), complemented by information from other international sources such as the UNESCO Institute for Statistics (UIS) and official administrative statistics published by national education authorities. These datasets define the scale of the education system and the number of units used in each calculation, primarily drawing on official statistics on teachers, students, and schools. Users can view and edit this information to ensure accuracy and alignment with the most recent available data.

About Prices

In the Calculator, the Price component represents the unit cost associated with each variable. For most cost categories, this refers to the market price of tangible items such as devices, routers or servers. In dimensions focused on human resources, such as teacher training and policy and coordination, costs are often expressed in terms of salaries or service fees. These were estimated based on the assumption that professionals with similar seniority levels receive comparable remuneration across equivalent roles.

To ensure accuracy, a price survey was conducted in the first semester of 2025. This survey collected data on local market prices and salary benchmarks for each participating country. The detailed methodology of the survey is described in a complementary document. However, the Calculator is designed for flexibility: users can update or replace the preloaded values with more accurate or locally verified prices as needed.

About the Parameters and the Formulas

The first part of the technical note defined the parameters used by the Digital Learning Cost Calculator. The following sections will detail how these parameters translate into specific formulas, demonstrating the Calculator's method for converting input data into digital learning cost estimates.

2. Cost of the Internet

The Internet and Devices dimensions were analyzed together in this stage of the study, given their complementary nature and similar acquisition processes. Both represent foundational technologies for a functioning digital education ecosystem, enabling everything from basic connectivity to device distribution for students and teachers. Accurately pricing these elements is essential for projecting realistic investment scenarios and ensuring their effective pedagogical use.

Seven key items were costed to ensure school connectivity:

- **Satellite connection service:** Recommended for remote areas where terrestrial infrastructure is limited or non-existent.
- **Fiber-optic connection service:** Preferred in urban and peri-urban areas due to higher speed and reliability.
- **Average cost per kilometer of fiber expansion:** Captures the investment required to extend infrastructure to school sites.
- **Access Point:** Device that distributes wireless internet signals within school premises.
- **Firewall:** Network security equipment that protects data and traffic from unauthorized access.
- **UPS (Uninterruptible Power Supply):** Ensures uninterrupted power for critical equipment during outages.
- **Switch:** Manages wired connectivity between school devices.
- **Rack:** Physical infrastructure for organizing and securing network equipment.

The full formula is shown below:

TABLE 20 Calculations for the Connectivity Dimension

DIMENSION 1: MEANINGFUL CONNECTIVITY						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example / Explanation
Fiber Expansion	25 km of fiber expansion per school	% of schools that need fiber expansion	considering the proxy of the ITU data of % of population between 25-50 in the country	price per km of fiber	% of schools that need fiber expansion × Number of Schools × Parameter Fiber Expansion (avg of km per school) × Price Fiber Expansion (Per Km)	<ul style="list-style-type: none"> If we have 50% of the population between 25k - 50km of the fiber, we will assume 50% of the schools need fiber expansion If we have 10 schools then we have: 50% * 10 schools * 25 km per school * U\$ 8,000 per km = 1M
Satellite Service	all remote schools	% of remote schools	considering the proxy of the ITU data of % of population between	Monthly price for the Satellite connection	% of schools that need satellite connection × Number of Schools × Price Satellite × Months to adjust	<ul style="list-style-type: none"> If we have 10% of the population above 50km of the fiber, we will assume 10% of the schools need satellite We have the price for satellite link, considering a monthly cost We multiply by 48 to get the 4-year run If we have 10 school and 20dol the satellite we have: 10% * 10 schools * U\$ 20 per month * 48 (for all 4 years) = 960
Fiber Link	all schools that are not remote with fiber 1 mbps per students	% of schools that are not remote number of students		Cost per mbps in a fiber plan	% of schools that need fiber link × Number of Schools × Average Students per School × (Price Fiber Link 200mbps - Monthly / 200) × Months to adjust	<ul style="list-style-type: none"> If we have 90% of the population below 50km of the fiber, we will have 90% of schools that need fiber link We have the price for 1mbps connection of fiber (considering a monthly plan). We multiply that by the number of students, to guarantee 1mbps per student We multiply by 48 to get the 4-year run If we have 10 school, 2000 (total) students and 0,3 dol per mbps we have: 90% * 10 schools * U\$ 0,3 per month * 200 students (avg) * 48 (for all 4 years) = 25 920
Access Point (AP)	1 AP/classroom	Number of classroom	In blue, the term approximates classrooms by dividing students by 25 (primary) and 35 (secondary), adding 3 classrooms per school for extra spaces.	AP cost	((Number of Primary Students / 25) + Number of Primary Schools × 3 + (Number of Secondary Students / 35) + Number of Secondary Schools × 3) × Parameter Access Point (# of AP per classrooms) × Price Access Point	<p>Considering 3500 students, half on secondary, half on primary, and 20 schools, and U\$ 300 per AP</p> $(1750 / 25) + 10 * 3 + (1750 / 35) + 10 * 3$ <p>73 classrooms for primary 53 classrooms for secondary</p> <p>126 classrooms * 300 = 37 800</p>
Firewall	1 per school	Number of schools		Firewall cost	Number of Schools × Parameter Firewall (# per school) × Price Firewall	<p>Considering 50 schools and 1000 per firewall</p> <ul style="list-style-type: none"> 50 * 1000 = 50 000 considering the parameter is 1

DIMENSION 1: MEANINGFUL CONNECTIVITY						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example / Explanation
UPS (Nobreak)	1 per school	Number of schools	-	Nobreak cost	Number of Schools × Parameter No-Break (# per school) × Price No-Break	considering 50 schools and 300 per UPS <ul style="list-style-type: none"> • 50 * 300 = 15 000 • considering the parameter is 1
Switch	1 per school	Number of schools	-	Switch cost	Number of Schools × Parameter Switch (# per school) × Price Switch	considering 50 schools and 300 per switch <ul style="list-style-type: none"> • 50 * 300 = 15 000 • considering the parameter is 1
Rack (6U/8U)	1 per school	Number of schools	-	Rack cost	Number of Schools × Parameter Rack (# per school) × Price Rack	considering 50 schools and 200 per switch <ul style="list-style-type: none"> • 50 * 200 = 10 000 • considering the parameter is 1

Source: Authors

3. Cost for Devices

The Devices and Internet dimensions, as explained before, were analyzed together in this stage of the study, given their complementary nature and similar acquisition processes.

The devices dimension includes six items costs:

- **Devices for Students**
- **Devices for Teachers**
- **Devices for Schools**
- **Multimedia Projector**
- **Headphones**
- **Charging Carts**

For calculating costs related to devices for students and teachers, there are three distinct scenarios based on the anticipated intensity of use (Dimension 2 - 1.2 - User Primary and Secondary). This results in three potential formulas for student devices, where only one parameter changes across the options. Consequently, since the costing of headphones and charging carts depends on the number of devices, there are also three corresponding formulas for each of these peripheral items. The full formula is shown below.

TABLE 21
Calculations for the Devices Dimension

DIMENSION 2: DEVICES						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example
Devices – Students – Min	Primary: 1 device per 20 students Type: Tablet Secondary: 1 device per 10 students Type: Cloudbook	Number of Primary Students - Number of Secondary Students	-	Tablet Price Cloudbook Price	$(\text{Number of Primary Students} \times \text{Parameter} \times \text{Price Tablet}) + (\text{Number of Secondary Students} \times \text{Parameter} \times \text{Price Cloudbook})$	Considering 100 primary students, 100 secondary students, 50 dol for a tablet and 200 dol for a cloudbook that would mean: • $(100 \times 1/20 \times 50) + (100 \times 1/10 \times 200) =$ • 5 tables - U\$ 250 • 10 cloudbook - U\$ 2000
Devices – Students – Mild	Primary: 1 device per 10 students Type: Tablet Secondary: 1 device per 6 students Type: Cloudbook	Number of Primary Students - Number of Secondary Students	-	Tablet Price Cloudbook Price	$(\text{Number of Primary Students} \times \text{Parameter} \times \text{Price Tablet}) + (\text{Number of Secondary Students} \times \text{Parameter} \times \text{Price Cloudbook})$	Considering 100 primary students, 100 secondary students, 50 dol for a tablet and 200 dol for a cloudbook that would mean: • $(100 \times 1/10 \times 50) + (100 \times 1/6 \times 200) =$ • 10 tablets - U\$ 500 • 17 cloudbook - U\$ 3 333
Devices – Students – Comprehensive	Primary: 1 device per 6 students Type: Tablet Secondary: 1 device per 2 students Type: Cloudbook	Number of Primary Students - Number of Secondary Students	-	Tablet Price Cloudbook Price	$(\text{Number of Primary Students} \times \text{Parameter} \times \text{Price Tablet}) + (\text{Number of Secondary Students} \times \text{Parameter} \times \text{Price Cloudbook})$	Considering 100 primary students, 100 secondary students, 50 dol for a tablet and 200 dol for a cloudbook that would mean: • $(100 \times 1/6 \times 50) + (100 \times 1/2 \times 200) =$ • 17 tablets - U\$ 833 • 50 cloudbook - U\$ 20000
Devices – Teachers	1/teacher Type: Laptop	Number of Teachers -	-	Laptop Price	$\text{Number of Teachers} \times \text{Parameter} \times \text{Price Laptop}$	considering 100 teachers and 400 dol for laptop that would mean: • $100 \times 400 = 40\ 000$
Devices – Admin	1 per school	Number of schools	-	Firewall Price	$\text{Number of Schools} \times \text{Parameter} \times \text{Price Firewall}$	considering 100 schools and 600 dol for a desktop that would mean: • $100 \times 600 = 60\ 000$ considering the parameter = 1
Charging Cart – Min	1 per 30 devices	Number of devices in Min scenario	-	Charging Cart Price	$(\text{Number of Primary Students} \times \text{Parameter} \times \text{Price Tablet}) + (\text{Number of Secondary Students} \times \text{Parameter} \times \text{Price Cloudbook}) / 30 \times \text{Price Charging Cart}$	• The blue part is just the redoing of the calculation of the amount of devices • Then we divide by 30 and multiply by the price of the charging cart • Example: considering 200 primary students, 200 secondary students, 500 dol for a charging cart • $200 \times 1/20 + (200 \times 1/10) = 10$ tablets and 20 cloudbooks • $(30 \text{ devices}) / 30 \times \text{US } 500 = \text{US } 500$

Digital Learning Cost Calculator

DIMENSION 2: DEVICES						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example
Charging Cart – Mild	1 per 30 devices	Number of devices in Mild scenario		Charging Cart Price	$\left(\text{Number of Primary Students} \times \text{Parameter Mild Scenario (Primary) (\# per student)} \right) + \left(\text{Number of Secondary Students} \times \text{Parameter Mild Scenario (Secondary) (\# per student)} \right) / 30 \times \text{Price Charging Cart}$	<ul style="list-style-type: none"> Example: considering Considering 200 primary students, 200 secondary students, 500 dol for a chagrin cart 200 * 1/10 + 200 * 1/6 = 20 tablets and 34 cloudbooks (54 devices) / 30 * US 500 = U\$ 1000 for two charging carts
Charging Cart – Comprehensive	1 per 30 devices	Number of devices in Comp scenario		Charging Cart Price	$\left(\text{Number of Primary Students} \times \text{Parameter Comprehensive Scenario (Primary) (\# per student)} \right) + \left(\text{Number of Secondary Students} \times \text{Parameter Comprehensive Scenario (Secondary) (\# per student)} \right) / 30 \times \text{Price Charging Cart}$	<ul style="list-style-type: none"> Example: considering Considering 200 primary students, 200 secondary students, 500 dol for a chagrin cart 200 * 1/6 + 200 * 1/2 = 34 tablets and 100 cloudbooks (134 devices) / 30 * US 500 = U\$ 2500 for five charging carts
Multimedia Projector	1 per school	Number of Schools		Multimedia projector Price	$\text{Number of Schools} \times \text{Parameter Multimedia Projector (\# per school)} \times \text{Price Multimedia Projector}$	<ul style="list-style-type: none"> Considering 50 schools and 700 per switch 50 * 700 = 35 000 considering the parameter is 1
Headphones – Min	1 per device	Number of devices in Min scenario		Headphone price	$\left(\text{Number of Primary Students} \times \text{Parameter Minimum Scenario (Primary) (\# per student)} \right) + \left(\text{Number of Secondary Students} \times \text{Parameter Minimum Scenario (Secondary) (\# per student)} \right) \times \text{Price Headphones}$	<ul style="list-style-type: none"> The blue part is just the redoing of the calculation of the amount of devices then we multiply by the price of the headphone Example: considering Considering 200 primary students, 200 secondary students, 5 dol for a headphone 200 * 1/20 + 200 * 1/10 = 10 tablets and 20 cloudbooks (30 devices) * US 5 = U\$ 150
Headphones – Mild	1 per device	Number of devices in Mild scenario		Headphone price	$\left(\text{Number of Primary Students} \times \text{Parameter Mild Scenario (Primary) (\# per student)} \right) + \left(\text{Number of Secondary Students} \times \text{Parameter Mild Scenario (Secondary) (\# per student)} \right) \times \text{Price Headphones}$	<ul style="list-style-type: none"> Example: considering Considering 200 primary students, 200 secondary students, 500 dol for a chagrin cart 200 * 1/10 + 200 * 1/6 = 20 tablets and 34 cloudbooks (54 devices) * US 5 = 270
Headphones – Comprehensive	1 per device	Number of devices in Comp scenario		Headphone price	$\left(\text{Number of Primary Students} \times \text{Parameter Comprehensive Scenario (Primary) (\# per student)} \right) + \left(\text{Number of Secondary Students} \times \text{Parameter Comprehensive Scenario (Secondary) (\# per student)} \right) \times \text{Price Headphones}$	<ul style="list-style-type: none"> Example: considering Considering 200 primary students, 200 secondary students, 500 dol for a chagrin cart 200 * 1/6 + 200 * 1/10 = 35 tablets and 100 cloudbooks (134 devices) * US 5 = 670

Source: Authors

4. Costs for Teacher Training

As highlighted in previous sections, teacher professional development is one of the most strategic pillars for the effective integration of educational technologies in schools. Without well-prepared educators, even the best infrastructure and most advanced devices risk becoming underutilized. The teacher training dimension, therefore, aims to ensure that educators develop digital competencies aligned with 21st-century pedagogical demands—supported by coherent training plans, appropriate tools, and continuous technical assistance. This dimension includes the following cost-estimable components:

- **Diagnostic Tool**
- **Training Design**
- **LMS Tool**
- **Trainers**
 - ◇ Hiring Trainers
 - ◇ Train the Trainer
- **Logistics**

Unlike other dimensions of the Digital Learning Cost Calculator, estimating the costs associated with teacher training required a distinct methodological approach. This is due to the fact that teacher professional development involves services rather than standardized products, which makes price collection more complex and more susceptible to significant variations across the public contracts analyzed. To address this challenge, the adopted methodology focused on identifying exemplary contracting models, considered to represent “golden standards” of excellence.

Since teacher professional development is fundamentally a service, the primary cost driver is human capital, specifically the compensation for the trainers involved. This inherent reliance on human expertise means that the true economic value of the service is closely tied to the cost of skilled labor within a given country.

Therefore, the calculator utilizes the average national teacher salary as a price adjustment factor to provide relevant and comparable cost estimates across different national context. This methodological choice is based on the premise that a country’s average teacher salary serves as an effective proxy for the local cost of

skilled human capital to provide teacher training.

Modality and Duration: Strategic Decisions That Impact Costs

While the unit values calculated earlier serve as a baseline, there are two key decisions that directly influence the total cost of teacher training: the **modality** and **duration** of the training.

Modality: In-person, hybrid or online?

Comparing cost estimates of in-person and online training it was found that while some in-person programs were found to be up to 5 to 15 times more expensive than their online counterparts. Therefore, the Calculator adopts a standard multiplier of 5 to strike a balance between budget predictability and implementation feasibility. In practice, this means that online training costs are multiplied by five to project in-person training expenses. The difference between the two modalities is primarily attributed to logistical expenses.

Consequently, instead of assigning a direct cost to a logistics variable, the Calculator uses an 'in-person' multiplier. This factor of five is applied to every item affected by the choice of in-person implementation. The same logic applies to Hybrid training. In this case, the 'hybrid' multiplier is equivalent to two.

Therefore, for the purpose of this tool, three contrasting scenarios were defined:

- **Scenario 1 – 100% Online Training (this is the Calculator’s default):** All cost estimates presented earlier are based on a fully virtual training model, utilizing Learning Management Systems (LMS) and remote support from trainers.
- **Scenario 2 – 100% In-Person Training:** In this case, costs are estimated to be five times higher than those of the online format, accounting for expenses such as travel, accommodation, meals, venue rental, physical infrastructure, and logistics. This multiplier represents an indicative estimate that aggregates the main cost components typically associated with fully in-person training programs. While it is not derived from a single empirical benchmark, it reflects a reasonable approximation based on the inclusion of these

operational requirements.

- **Scenario 3 – Hybrid Training:** In this case, costs are estimated to be two times higher than those of the online format, accounting for expenses such as travel, accommodation, meals, venue rental, physical infrastructure, and logistics. This multiplier represents an indicative estimate that aggregates the main cost components typically associated with hybrid training programs, where both online and in-person sessions are required. While it is not derived from a specific empirical benchmark, it reflects a reasonable approximation based on the operational requirements involved.

It is worth highlighting that international research indicates that **hybrid models**—combining in-person and online sessions—offer the best balance between cost-effectiveness and educational impact. However, the sheer variety of possible combinations (e.g., 10% in-person and 90% online, or the reverse) makes it impractical to assign specific costs to each scenario.

Duration: 40 hours or 60 hours?

The second key variable is the total duration of the training. The default recommendation is 60 hours spread over four years, providing a foundation for the progressive development of digital competencies.

However, the 40 hours options also acknowledges that:

- Many teachers already possess intermediate or advanced levels of digital fluency;
- Available time for in-service training may be limited.

Therefore, the Calculator also allows users to simulate shorter 40-hour training programs. To maintain internal consistency in the estimates, all cost components directly tied to training duration—such as trainer fees—are automatically adjusted. In such cases, a 0.7 factor is applied, reflecting the ratio of 40 to 60 hours. This ensures that streamlined training programs can be modeled without compromising the minimum quality standards recommended by the tool.

Some cost components vary depending on the scenario, while others remain constant:

TABLE 22
Cost Variations for Teacher Training

Component	Variation
Diagnostic Tool	Does not vary
Training Design	Varies by training hours, but not by modality
LMS Tool	Does not vary
Trainers	Varies by modality and training hours
Hiring Trainers	Varies by modality and training hours
Train the Trainer	Varies by modality and training hours

Source: Authors

The Teacher Training full formula is shown below:

TABLE 23
Calculations for the Teacher Training Dimension

DIMENSION 3: TEACHER TRAINING						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example
Diagnostic Tool	1 tool for all (independent of the amount of teachers)	-	Cost independent from the education data	Price of developing and maintaining a diagnostic tool	Price Diagnostic Tool (implementing tool)	If the diagnosis price is 40 000 , then no matter the amount of teachers, the total cost is 40 000.
LMS Platform	1 tool for all (independent of the amount of teachers)	-	Cost independent from the education data	Price of developing and maintaining an LMS plat.	Price LMS platform for the training	If the lms price is 40 000. , then no matter the amount of teachers, the total cost is 40 000.

DIMENSION 3: TEACHER TRAINING

Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example
Trainers – Online 60h	50 teacher per cohort	Number of trainers needed per every 50 teachers	-	Price of hiring a trainer	Cost of hiring Trainer (60h) × (Number of Teachers / Parameter Teachers per Class (size of teacher cohort))	<ul style="list-style-type: none"> The number of graduate teachers is the amount of teachers that would participate in the training The price is the cost of one trainer, responsible for one cohort To understand the total amount, we divide the amount of teachers to be trained by 50, to understand how many cohorts, thus how many trainers we will need Example, considering 2500 teachers and U\$ 1500 for the trainer <ul style="list-style-type: none"> 2500/50 = 50 cohorts 50 * 1500 = U\$ 75000
Trainers Course – Online 60h	50 trainers per cohort	Number of trainers needed per every 50 teachers	The number of trainers is the number of teachers divided by 50, considered the 50-size cohort	Price of hiring an experienced trainer (trainer x 1.5)	Cost of hiring Trainer (60h) × 1.5 × (Number of Teachers / Parameter Teachers per Class (size of teacher cohort)) / Parameter Teachers per Class (size of teacher cohort)	<ul style="list-style-type: none"> The price of the trainers is multiplied by 1.5X considering the need to hire most experienced trainers. To understand the total amount, we divide the total number of trainers (teachers / 50) by 50 to understand how many cohort of trainers we will have Example, considering 2500 teachers and U\$ 1500 for the trainer <ul style="list-style-type: none"> 2500/50 = 50 cohorts 50 cohorts = 50 trainers / 50 1 cohort of trainers 1 * 1500 * 1,5 = U\$ 2250
Training Design – Online 60h	1 tool for all (independent of the amount of teachers)	-	Cost independent from the education data	Price of designing the training and the content	Price Training Design	If the training design price is 600 000, then no matter the amount of teachers, the total cost is 600 000. It covers content production.
Trainers – Hybrid 40h	50 teacher per cohort	Number of trainers needed per every 50 teachers Number of trainers to be trained	-	Price of hiring a trainer, adjusted by the number of hours - multiplier	[Trainers – Online 60h] × Multiplier (40h Training) × hybrid (40h training)	This is the same variable of the trainers -online 60h, but with less hours - 40 instead of 60. Therefore, there is a multiplier, (0.7) so the cost will be adjusted. Assuming, the cost is proportional.
Trainers – Hybrid 40h	50 trainers per cohort	Number of trainers needed per every 50 teachers Number of trainers to be trained	The number of trainers is the number of teachers divided by 50, considered the 50-size cohort	Price of hiring an experienced trainer (trainer x 1.5) adjusted by the number of hours - multiplier	[Trainer Course – Online 60h] × Multiplier (40h Training) × hybrid (40h training)	This is the same variable of the trainers course - online 60h, but with less hours - 40 instead of 60. Therefore, there is a multiplier, (0.7) so the cost will be adjusted. Assuming, the cost is proportional.
Trainers – Hybrid 40h	1 tool for all (independent of the amount of teachers)	-	-	Price of designing the training and the content adjusted by the number of hours - multiplier	[Training Design – Online 60h] × Multiplier (40h Training)	This is the same variable of the training designing - online 60h, but with less hours - 40 instead of 60. Therefore, there is a multiplier, (0.7) so the cost will be adjusted. Assuming, the cost is proportional.

DIMENSION 3: TEACHER TRAINING						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example
Trainers – In-person 40h	50 teacher per cohort	Number of trainers needed per every 50 teachers Number of trainers to be trained	-	Price of hiring a trainer, adjusted by the number of hours - multiplier and adding a logistic factor (in person multiplier)	[Trainers – Online 60h] × Multiplier In-Person Training × Multiplier (40h Training)	This is the same variable of the trainers -online 60h, but with less hours - 40 instead or 60. Therefore, there is a multiplier, (0.7) so the cost will be adjusted. Assuming, the cost is proportional. Besides, there is a logistic factor (inperson multiplier) that multiply the cost by 5, considering logistic issues
Trainer Course – In-person 40h	50 trainers per cohort	Number of trainers needed per every 50 teachers Number of trainers to be trained	The number of trainers is the number of teachers divided by 50, considered the 50-size cohort	Price of hiring an experienced trainer (trainer × 1.5) adjusted by the number of hours - multiplier and adding a logistic factor (in person multiplier)	[Trainer Course – Online 60h] × Multiplier In-Person Training × Multiplier (40h Training)	This is the same variable of the trainers -online 60h, but with less hours - 40 instead or 60. Therefore, there is a multiplier, (0.7) so the cost will be adjusted. Assuming, the cost is proportional. Besides, there is a logistic factor (inperson multiplier) that multiply the cost by 5, considering logistic issues
Training Design – In-person 40h	1 tool for all (independent of the amount of teachers)	-	-	Price of designing the training and the content adjusted by the number of hours - multiplier	[Training Design – Online 60h] × Multiplier (40h Training)	This is the same variable of the trainers -online 60h, but with less hours - 40 instead or 60. Therefore, there is a multiplier, (0.7) so the cost will be adjusted. Assuming, the cost is proportional.

Source: Authors

5. Cost for Educational Platforms

In Educational Platforms there is one variable: Learning Plataforms

TABLE 24
Calculations for the Platforms Dimension

DIMENSION 4: PLATFORMS						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example
Teaching and Learning Platform	1 license per student	Number of Students	-	Price of the annual license	Number of Students × Price Teaching & Learning Platform × Parameter Teaching & Learning (per student) × (Months to adjust / 12)	Assuming 100 primary students and 100 secondary students, and 4 dollars annually per student, we have: 200 * 4 = 800 * (48/12) = 3200 The opex/12 is just to get multiplication by N years (in this case 4)

Source: Authors

6. Cost for Governance

5.1 Price per item and per country

Just like teacher training, investments in policy and coordination are primarily driven by human capital, with salaries being the main cost component. As previously discussed, the organizational structure proposed by the Digital Learning Cost Calculator envisions three levels of operation: national (central), regional, and local. The size and profile of each team are defined based on quality benchmarks, while salaries are estimated from comparable international and regional data sources.

For the central team, responsible for planning, monitoring, and evaluating the digital education policy, salary estimates are based on international research on consultancy fees and data from multilateral NGOs, using average values reported per country. Where specific data was unavailable, sub-regional averages were applied, as detailed in Appendix E.

For regional and local teams, salaries were estimated using the average salary of public school teachers (see Appendix E), as these roles are typically filled by professionals with teaching backgrounds and direct experience in schools.

TABLE 25
Calculations for the Governance Dimension

DIMENSION 5: GOVERNANCE						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example
Central Team	6 - 11 people in the central team	-	Cost independent from the education data	Salary of a government consultant	$\text{Salary Consultant} \times \left(\frac{\text{Parameter Central Team (Min)} + \text{Parameter Central Team (Max)}}{2} \right) \times \text{Months to adjust}$	<p>Assuming an average of ~9 persons to work in the central government (more accurate, assuming the average of the min and the max references 6 and 11)</p> <p>Considering the salary of US\$ 1500 that means</p> $9 * 1500 * 48 = 648\ 000$
Regional Team	1 individual per 50 schools	Number of Schools		Salary of a teacher	$\text{Parameter Regional Team (\# individuals per school)} \times \text{Number of Schools} \times \text{Salary Teacher} \times \text{Months to adjust}$	<p>Assuming an individual to assist 50 school</p> <p>Considering 500 schools, and a teacher salary of US\$ 800, this would mean</p> $500/50 * 800 * 48 = 348\ 000$

DIMENSION 5: GOVERNANCE						
Subvariable	Parameter	Quantity	Assumptions	Price	Formula	Example
Local Team	1 individual per 5 urban schools 1 individual per 3 rural schools	Number of Rural schools Number of Urban Schools		Salary of a teacher	$\left((\text{Parameter Local Team (Urban)} \times (\text{Number of Schools} - \text{Number of Rural Schools})) + (\text{Parameter Local Team (Rural)} \times \text{Number of Rural Schools}) \right) \times \text{Salary Teacher} \times \text{Months to adjust}$	<p>To guarantee consistency we calculate the number of urban schools making (total schools - rural schools)</p> <p>Considering 500 schools, 300 rural and a teacher salary of U\$ 800, this would mean</p> $(500 - 300) \times 0.2 + 300 \times 0.33 = 40 \text{ individuals for urban} + 100 \text{ individuals for rural}$ $140 \times 800 \times 48 = 5.3\text{MM}$

Source: Authors

7. Total Value of the Calculator

Recognizing that public procurement processes and contract negotiations are inherently subject to significant market fluctuations +/-25% margin was applied to the total calculated cost. This inclusion is a critical component of risk mitigation, ensuring the final proposal is robust enough to accommodate unforeseen circumstances. This specific 25% figure was not arbitrary; it was determined through comprehensive price research. The analysis involved collecting pricing data from a wide range of suppliers, previous government contracts, and market reports. The resulting statistical distribution consistently indicated that 25% represented the average standard deviation observed in the collected pricing data. By using this empirically derived figure, the margin reflects the typical range of cost volatility and provides a realistic buffer.

8. Average cost in different scenarios

In addition to the overall cost, the Calculator also provides an estimate of the average cost **per school**, a critical input for assessing policy feasibility across systems of different sizes. Moreover, to better support cost-benefit analyses and facilitate transparent dialogue among decision-makers, the average investment **per student** is also included in the final report. These indicators are particularly useful for helping education authorities weigh the potential impact and affordability of different strategies.

To further support evidence-based prioritization, the Calculator allows for scenario-based disaggregation of costs. The Calculator presents three possible scenarios for implementing digital learning. These scenarios were selected based on evidence that the targeted schools would experience greater benefits than others. They are provided as examples to illustrate how costs can be adjusted to design a policy that addresses all five dimensions of digital learning while remaining financially feasible.

Considering this, the Calculator includes three scenarios to estimate costs in different contexts. Each one uses the same calculation method but adjusts the data according to school type and level of education.

1. Rural schools scenario

In this scenario, only rural schools are considered. In rural areas, schools play a role as community centers and they serve as connectivity hubs for the local community (ITU, 2023) but the average level of connectivity is half that observed in urban areas (IICA, 2020). Disadvantaged communities have fewer devices, less access to the Internet and fewer resources at home, which increases the risk of exclusion (Unesco, 2023a).

When official data on rural schools are available, they are used directly. When such data are not available, the Calculator estimates the number of rural schools based on regional averages observed in Latin America. The number of teachers and students in rural areas is then derived from national totals using proportional factors.

2. Secondary schools scenario

This scenario limits the analysis to secondary schools and their student populations. Digital literacy is essential for many occupations and, thus, often required in the job market (World Bank, 2021). Prioritizing secondary schools aims to facilitate the development of these skills among youth.

The number of teachers is calculated using the data from CIMA where it is available, where it is not a student-teacher ratio at the secondary level is used. Device parameters, such as student-device ratios, are adjusted to match secondary

education standards. The number of schools in this scenario may differ from the total of primary and secondary schools, since some institutions serve multiple levels.

3. Teacher and school-only scenario

This scenario excludes student devices from the calculation. All other components remain the same as in the full-cost scenario. The focus here is on providing devices to teachers and schools. This model supports incremental or phased implementation strategies. Ensuring that teachers receive equipment from the early stages also generates structural effects within the education system (UNESCO, 2023a).

The table below summarizes the three alternative scenarios incorporated into the Calculator, highlighting their specific scope, methodological adjustments, and intended policy use.

TABLE 26
Overview of the Different Scenarios

Scenario	Scope	Key Features	Purpose
Rural schools scenario	Only rural schools, teachers, and students	<ul style="list-style-type: none"> • Uses national rural school data when available • Otherwise applies a regional proxy • Teacher and student data estimated proportionally 	Estimate investments needed to reach rural and remote areas with tailored infrastructure and support
Secondary schools scenario	Only secondary-level schools, students, and teachers	<ul style="list-style-type: none"> • Uses secondary school/ student data • Teacher numbers when available or estimated proportionally • Device parameters adapted to secondary education standards 	Tailor cost projections to secondary education policies and needs
Teacher and school-only scenario	All schools, but only devices for teachers and school infrastructure	<ul style="list-style-type: none"> • Excludes student devices- Maintains all other inputs and calculations • Focuses on core staff and institutional equipment 	Provide a lower-cost option focused on foundational digital capacity building

Source: Authors

Appendixes



Appendix A - Formula of Student-Device Ratio

In the school context, it is not pedagogically recommended for students to use digital devices in every lesson. Therefore, providing one device per student should not be seen as a mandatory condition for the effective integration of technology into the learning environment. It is entirely feasible to adopt shared device models between classes, provided that the pedagogical plan clearly defines the intended frequency of use for each group — for example, two classes per week per group.

Based on this approach, the school can acquire a number of devices compatible with the number of students per class, ensuring that all students have individual access to the equipment during the scheduled time. This strategy enables balanced use of technology, respecting both learning objectives and the principles of conscious screen usage.


Establishing a maximum student-to-device ratio aims to simplify the process of calculating the ideal number of devices for each class. This method relies on four key variables to align the technological infrastructure with the pedagogical reality of the school:

- **Number of classes per week using technology per group** — for instance, if each group will use the devices in two weekly lessons;
- **Number of groups in the school's largest shift** — for example, if the morning shift has the highest number of groups, it serves as the basis for the calculation;
- **Total number of weekly classes** — for instance, with five days of classes and five lessons per day, the total is 25 classes per week;
- **Number of students in the largest class** — for example, if the largest class has 35 students, the school must ensure that enough devices are available for all students to use simultaneously during the planned sessions.

By combining these variables, schools can implement an efficient rotation strategy, ensuring that all students access the devices according to the pedagogical plan. This approach prevents resource waste and ensures intentional, pedagogical use

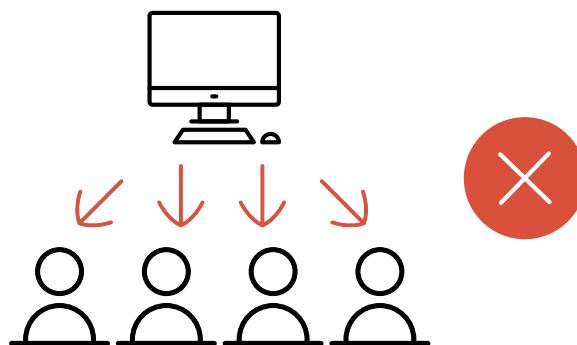
of technology.

The student-to-device ratio is calculated using the following formula:

$$\text{Student-to-Device Ratio} = \frac{\text{number of students per shift}}{\text{number of devices}}$$


For example, imagine a school with a weekly schedule of 30 lessons (6 lessons per day over 5 days). If the plan is for each group to use digital devices in 6 of these lessons per week, the student-to-device ratio would be 5:1. This means that with proper scheduling, one device can serve five students across the week, ensuring that each student has individual use during the allocated classes.

It is important to consider the largest shift because it represents the maximum number of students present simultaneously at the school. Meeting the needs of the largest shift ensures that all other shifts are adequately covered.



If the school has 4 lessons per day, the total number of weekly lessons is 20. If it has 6 lessons per day, the total is 30, and so on.

The number of devices must be sufficient to ensure that every student in the largest class has access to an individual device during the session. By accommodating the largest class, all other groups are inherently covered.

This logic can be applied to various scenarios. For instance, in a school with 25 weekly lessons and a plan for 5 lessons using technology per group, the ratio would also be 5:1. If the intended use is more intensive — such as 10 lessons per week — the ideal ratio would be 3:1, requiring more devices to ensure individual access for all students during the planned sessions.

This flexible model allows education systems to make strategic investments, aligning the number of devices with each school’s pedagogical plan and infrastructure, thereby optimizing public resource usage.

Importantly, a 5:1 ratio does not mean five students will share a single device simultaneously.

Formula Recap

Student-to-Device Ratio = $\frac{\text{number of students per shift}}{\text{number of devices}}$

The total number of students in the largest shift is calculated by:
 Number of groups in the largest shift × Number of students in the largest class

This calculation estimates the total number of students present during the busiest shift, ensuring that even the largest class has sufficient devices for individual use based on the targeted frequency.

The number of required devices is calculated by:

Student-to-Device Ratio = $\frac{\text{number of students per shift}}{\text{number of devices}}$

1. $\left(\frac{\text{Targeted frequency for technology use in classes per class}}{\text{Number of weekly classes}} \right) \times$

2. $\text{Number of students in the school's largest class} \times$

3. $\text{Number of classes in the school's largest shift}$

The components of the formula are:

- 1. Number of weekly lessons using technology:** Represents the percentage of classes that will involve technology use.
- 2. Number of students in the largest class:** Determines the device set size required for each class.
- 3. Number of groups in the largest shift:** Defines the total number of device sets needed to meet the target frequency.

In summary, the general formula is:

$$\text{Student-to-Device Ratio} = \frac{\text{number of students per shift}}{\text{number of devices}} = \frac{\cancel{\text{Number of classes in the school's largest shift}} \times \cancel{\text{Number of students in the school's largest class}}}{\left(\frac{\text{Target frequency for technology use in classes}}{\text{Number of weekly classes}} \right) \times \cancel{\text{Number of students in the school's largest class}} \times \cancel{\text{Number of classes in the school's largest shift}}} = \frac{\text{number of weekly classes}}{\text{Target frequency for technology use in classes per class}}$$

Using this, it is possible to determine the student-to-device ratio based on the target usage frequency and total number of weekly lessons. Once this ratio is set and the total number of students in the largest shift is known, schools, districts, or countries can estimate how many devices are needed.

Practical Example:

A school has 10 groups in its largest shift, with the largest group having 30 students. The school runs 30 weekly lessons (6 lessons per day). The plan is to use technology in 6 lessons per week for each group, ensuring that students do not share devices during those classes.

The calculation yields:

Digital Learning Cost Calculator

$$\begin{array}{c}
 \boxed{\text{Student-to-Device Ratio}} = \frac{\text{number of weekly classes}}{\text{Target frequency for technology use in classes per class}} = \frac{30 \text{ hours per week}}{6 \text{ hours per week per class}} = \boxed{5:1 \text{ Students-to-Device Ratio}} = \frac{\boxed{\text{number of Students per Shift}}}{\boxed{\text{Number of Devices}}}
 \end{array}$$

- **Target frequency for technology use:** 6 lessons per week
- **Student-to-device ratio:** 5:1
- **Total devices needed:**
 $(10 \text{ groups} \times 30 \text{ students}) \div (5 \text{ students per device}) = 60 \text{ devices}$
- **Device set size:** 30 devices
- **Number of sets:** 2 (this allows two groups to use devices simultaneously, with one device per student)

A second example:

A school has 10 groups in the largest shift, with the largest group having 30 students. The school runs 20 weekly lessons (4 lessons per day) and plans to use devices in 10 lessons per week per group.

The calculation yields:

$$\begin{array}{c}
 \boxed{\text{Student-to-Device Ratio}} = \frac{\text{number of weekly classes}}{\text{Target frequency for technology use in classes per class}} = \frac{20 \text{ hours per week}}{10 \text{ hours per week per class}} = \boxed{2:1 \text{ Students-to-Device Ratio}} = \frac{\boxed{\text{number of Students per Shift}}}{\boxed{\text{Number of Devices}}}
 \end{array}$$

- **Target frequency for technology use:** 10 lessons per week
- **Student-to-device ratio:** 2:1
- **Total devices needed:**
(10 groups × 30 students) ÷ (2 students per device) = 150 devices
- **Device set size:** 30 devices
- **Number of sets:** 5 (this allows five groups to use devices simultaneously, with one device per student)

It is important to note that regardless of the total number of weekly lessons, the student-to-device ratio remains consistent for the same usage percentage:

- **10% of weekly lessons:** ratio of 10:1
- **20% of weekly lessons:** ratio of 5:1
- **50% of weekly lessons:** ratio of 2:1

Therefore, if policymakers aim to meet any other percentage of weekly lessons, the calculation can be adjusted proportionally to determine the necessary student-to-device ratio.

Appendix B - Dosage of Technology Use

<p>PAPER</p> <p>Diminishing Marginal Returns to Computer-Assisted Learning (2023)</p>			<p>INSIGHTS</p> <ul style="list-style-type: none"> • Doubling the time on Computer-assisted learning does not represent more learning
<p>AUTHORS</p> <p>Eric Bettinger Robert W. Fairlie Anastasia Kapuza Elena Kardanova Prashant Loyalka Andrey Zakharov</p>			
YEAR	COUNTRY	SUBJECT	
2023	Russia	Math	
MINUTES	AGE / GRADE	TYPE OF STUDY	
45 min per week	3th grade	RCT 6k children 340 schools	

<p>PAPER</p> <p>The Impact of Computer Assisted Learning on Rural Taiwanese Children: Evidence from a Randomized Experiment (2020)</p>			<p>INSIGHTS</p> <ul style="list-style-type: none"> • There is a low compliance (teachers do not use the software) • When used, there is learning impact
<p>AUTHORS</p> <p>Yue Ma, Cody Abbey, Derek Hu, Oliver Lee, Weiting Hung, Xinwu Zhang*, Chiayuan Chang, Chyi-In Wu, Scott Rozelle</p>			
YEAR	COUNTRY	SUBJECT	
2020	Taiwan	Math	
MINUTES	AGE / GRADE	TYPE OF STUDY	
30 min per week	avg 10Y	RCT ~2k children 95 schools	

PAPER

[Evidence from a Field Experiment in El Salvador \(2021\)](#)

AUTHORS

Konstantin Buchela, Martina Jakobb, Christoph Kuhnhanssb, Daniel Steffenc, Aymo Brunetti

YEAR	COUNTRY	SUBJECT
2021	El Salvador	Math
MINUTES	AGE / GRADE	TYPE OF STUDY
90 min per week	3th - 6th Grade	RCT 29 schools

INSIGHTS

- Latam focused (El Salvador)
- Compared computer assisted vs traditional teaching

PAPER

[Play to Learn: The Impact of Technology on Students' Math Performance](#)

AUTHORS

Guilherme Hirata

YEAR	COUNTRY	SUBJECT
2022	Brazil	Math
MINUTES	AGE / GRADE	TYPE OF STUDY
20 min per day	Primary	RCT

INSIGHTS

- Latam focused (Brazil)

PAPER

[Testing the Effects of GraphoGame Against a Computer-Assisted Math Intervention in Primary School](#)

AUTHORS

Julie Lassault, Liliane Sprenger-Charolles, Jean-Patrice Albrand, Edouard Alavoine, Ulla Richardson, Heikki Lyytinen, Johannes C Ziegler

YEAR	COUNTRY	SUBJECT
2022	France	Reading
MINUTES	AGE / GRADE	TYPE OF STUDY
30 min per day, 4 times per week	1st Grade	Quasi-experimental ~900 children

INSIGHTS

- Effect on first-graders (on literacy)

PAPER

[Does Gamification in Education Work? Experimental Evidence from Chile](#)

AUTHORS

Roberto Araya Elena Arias Ortiz Nicolas Bottan Julian Crist

YEAR	COUNTRY	SUBJECT
2019	Chile	Math
MINUTES	AGE / GRADE	TYPE OF STUDY
180 min per week	4th Grade	RCT 24 schools

INSIGHTS

- Focused on gamification
- Latam focused (Chile)

PAPER

[Generative AI Can Harm Learning \(2024\)](#)

AUTHORS

Hamsa Bastani, Osbert Bastani, Alp Sungu, Haosen Ge, Ozge Kabakci, Rei Mariman

YEAR	COUNTRY	SUBJECT
2024	Turkey	
MINUTES	AGE / GRADE	TYPE OF STUDY
~40 min, 4 times per week (160 min per week)	9th - 11th Grade	RCT ~1 school, 1000 students

INSIGHTS

- AI tutoring can substantially improve learning outcomes
- Just the AI tool can be harmful, as the student who suddenly stop using the tool may decrease their performance

PAPER

[Disrupting Education? Experimental Evidence on Technology-Aided Instruction in India \(2018\)](#)

AUTHORS

Karthik Muralidharan and Abhijeet Singh and Alejandro J.Ganimian

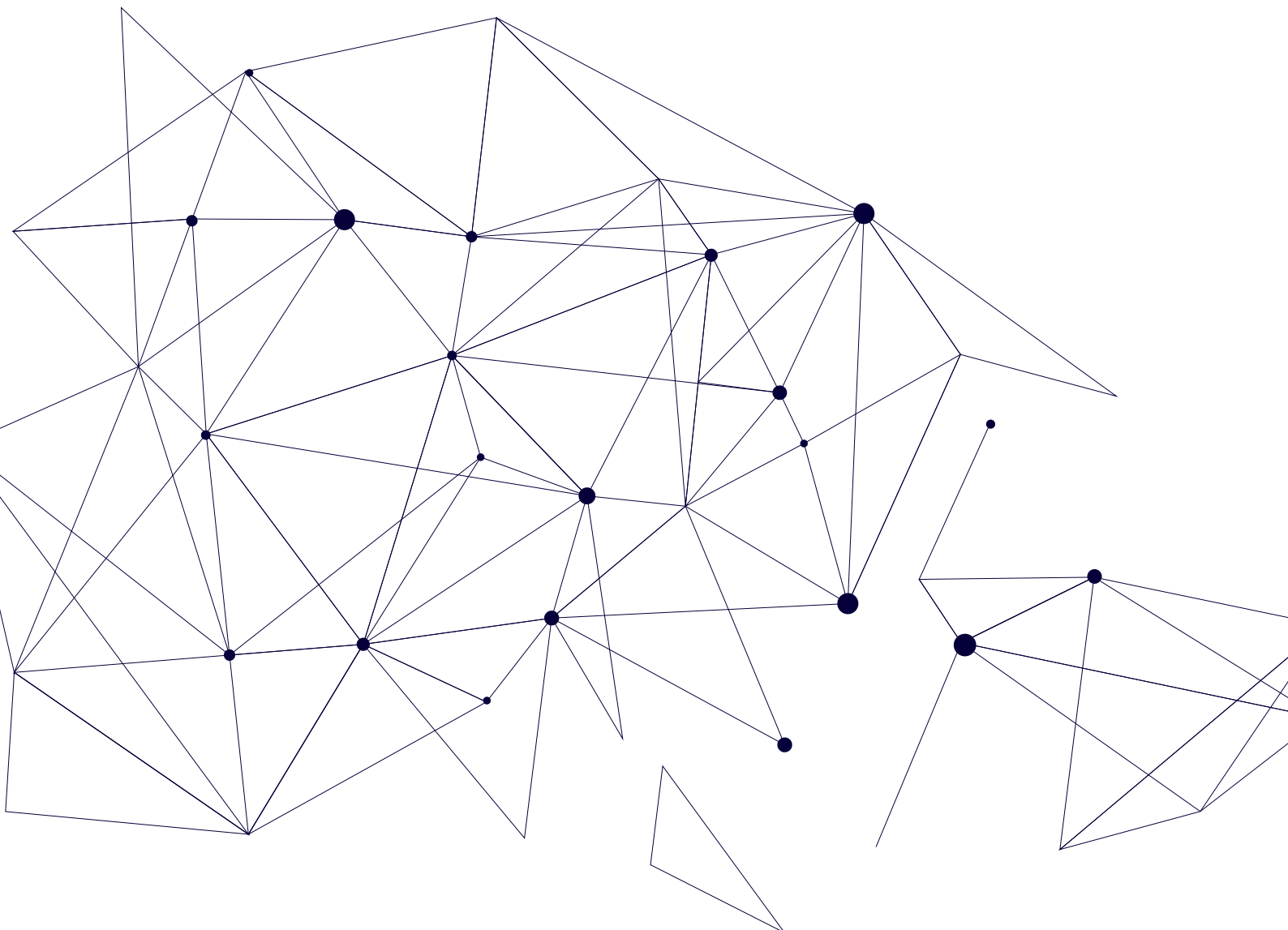
YEAR	COUNTRY	SUBJECT
2018	India	Math and Language
MINUTES	AGE / GRADE	TYPE OF STUDY
45 - 90 min per day (225 - 450 per week)	4th - 9th Grade (avg 12Y)	RCT ~600 students

INSIGHTS



Digital Learning Cost Calculator

PAPER			INSIGHTS
New global data reveal education technology's impact on learning			<ul style="list-style-type: none">• “First, technology must be used correctly to be effective”
AUTHORS			
Jake Bryant, Felipe Child, Emma Dorn, and Stephen Hall			
YEAR	COUNTRY	SUBJECT	
2020	PISA Countries	Math, Reading and Science	
MINUTES	AGE / GRADE	TYPE OF STUDY	
inconclusive	~15Y	correlational	



Appendix C – Classification: CAPEX and OPEX

Dimension	Item	Classification
Connectivity	Fiber Expansion	Capex
	Satellite Service	Opex
	Fiber Link	Opex
	Access Point	Capex
	Firewall	Capex
	Nobreak	Capex
	Switch	Capex
	Rack 6U/8U	Capex
	Devices	Device per Students - Mild
Device per Students - Mild		Capex
Devices per Students - Comprehensive		Capex
Devices per Students - Comprehensive		Capex
Devices per teacher		Capex
Devices per school		Capex
Devices Total		Capex
Charging Cart		Capex

Digital Learning Cost Calculator

Dimension	Item	Classification
Devices	Multimedia Projector	Capex
	Headphones - Mild Scenario	Capex
	Headphones	Capex
Teacher training	Diagnostic Tool Development	Capex
	Diagnostic Tool Hosting	Opex
	Content Production	Capex
	LMS Platform Development	Capex
	LMS Platform License	Opex
	LMS Platform Maintenance	Opex
	Specialist Trainers	Opex
	Training Design	Opex
	Course for Trainers	Opex
Educational Platforms	Teaching and Learning Platform	Opex
Governance	Central Team	Opex
	Regional Team	Opex
	Local Team	Opex

Appendix D - Technical Specifications

Device	Description
Tablet	Samsung Tab A9+ SM-X210NZSEMXXO
	Lenovo Tab P11
	Lenovo Series M Tab M11
	Huawei MatePad SE 11
	Xiaomi Redmi Pad SE Solo
	Lenovo Tab Plus
	REDMI PAD SE
Laptop i3	Lenovo IdeaPad Slim 3 Intel Core i3
	Asus Vivobook F1400EA Core i3
	Dell Laptop Inspiron 3520 Intel Core i3
	HP 240 G9 Intel Core i3 Laptop
Laptop i5 or higher	ASUS VIVOBOK X515E CORE I5
	Acer NXKQ4AL006 Nvidia GeForce RTX 2050, Intel® Core™ i5 Processor
	HP 15.6", Intel Core i5-1235U
	Lenovo IdeaPad Slim 3 15.6" FHD Touchscreen
	HP 240 G8 Laptop, Intel Core i5

Digital Learning Cost Calculator

Device	Description
Cloudbook/Chromebook	HP Chromebook x360 11 G3 Education
	Acer Chromebook 311 C733-C2DS
	ASUS Chromebook C204EE-Cel4G32COs-01
Desktop i3	HP 280 G9 SFF Computer Intel Core i3-13100
	HP 9P4K0LA Intel Core i3 Intel Iris XE 8 GB
Desktop i5	Lenovo ThinkCentre M70q Gen 4 12E30003US
	Dell Optiplex MFF 7010 Intel Core i5
Charging Cart	Pearington 30-Device Charging Cart
	H-5489 – UNLINE Tablet Charging Cart
Multimedia Projector	Epson Powerlite X49 Portable Projector
	Epson PowerLite W49 Projector
	BenQ Projector MW560
Headset	Logitech 3.5 mm Stereo Analog Headset H151
	Logitech H390 Over-Ear Headphones
UPS (No-break)	Minimum Output Power Capacity: 1500 VA / 1050 Watts
Access Point	Logitech 3.5 m ACCESS POINT / ADDITIONAL FEATURES: SUPPORTS UP TO 100 SIMULTANEOUS USERS / QUALCOMM TECHNOLOGY / CENTRALIZED MANAGEMENT. Example: TP-Link EAP650 m Stereo Analog Headset H151

Device	Description
Firewall	Specs: Throughput: 1Gbps; NGFW Throughput: 400 Mbps; Max Concurrent Sessions: 300,000; Dimensions: 1U – Features: URL Filtering, Intrusion Prevention, Device Status, Traffic and Threat Monitoring. Examples: Hilstone SG-6000-A5100; PA-415; Cisco FPR-1010; ASA-5508 and 5516

Appendix E - Prices

Observations: In the calculator, the prices are dynamic and they can be updated.

country	subregion	Price Satellite Connection Monthly	Price Satellite Connection Monthly	Price for expansion of 1km of fiber	Price for the Access Point	Price for the Firewall	Price for the Nobreak	Price for Tablet	Price for Laptop	Price for Cloudbook	Price for hiring a platform for students	Price for the Teacher Salary	Price for designing the course for teachers	Price for hiring a teacher trainer
sources		Installation (divided per 24) + Best plan found (w/ less latency)	Online Price Survey in Feb2025 for internet plans, adjusted for 200mbps link	Estimation price of Fiber Expansion in BNDES project in Brazil - considering these prices are not public	Online Price Survey in Retail companies and/or Procurements in Feb2025	Online Price Survey in Retail companies and/or Procurements in Feb2025	Online Price Survey in Retail companies and/or Procurements in Feb2025	Online Price Survey in Retail companies and/or Procurements in Feb2025	Online Price Survey in Retail companies and/or Procurements in Feb2025	Online Price Survey in Retail companies and/or Procurements in Feb2025	Online Price Survey, Adjusted for smaller countries, considering the cost-per student would be higher	Bonilla-Molina, 2021 report	Price estimation, considering the development calculator .	Double Teacher Salary, considering the seniority of this professional
Argentina	Cono Sur	\$213	\$17	\$15,659	\$336	\$1,825	\$679	\$430	\$725	\$833	\$3	\$970	\$600,000	\$1,940
Bahamas	Caribe	\$325	\$36	\$15,659	\$185	\$913	\$353	\$472	\$580	\$425	\$8	\$1,204	\$600,000	\$2,408
Barbados	Caribe	\$325	\$36	\$15,659	\$185	\$913	\$353	\$472	\$580	\$425	\$8	\$1,204	\$600,000	\$2,408
Belize	Centroamérica	\$194	\$31	\$15,659	\$194	\$954	\$357	\$278	\$468	\$321	\$8	\$1,068	\$600,000	\$2,136
Bolivia	Grupo Andino	\$42	\$16	\$15,659	\$199	\$1,037	\$287	\$292	\$381	\$303	\$3	\$1,067	\$600,000	\$2,134
Brazil	Cono Sur	\$605	\$21	\$15,659	\$143	\$2,140	\$176	\$303	\$484	\$291	\$3	\$596	\$600,000	\$1,192

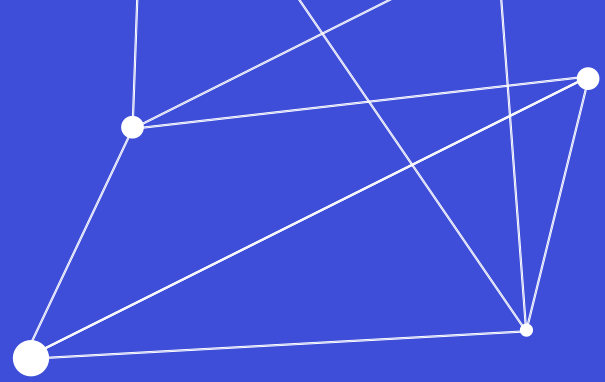
Digital Learning Cost Calculator

country	subregion	Price Satellite Connection Monthly	Price Satellite Connection Monthly	Price for expansion of 1km of fiber	Price for the Access Point	Price for the Firewall	Price for the Nobreak	Price for Tablet	Price for Laptop	Price for Cloudbook	Price for hiring a platform for students	Price for the Teacher Salary	Price for designing the course for teachers	Price for hiring a teacher trainer
Chile	Cono Sur	\$38	\$10	\$15,659	\$213	\$1,071	\$313	\$237	\$571	\$370	\$3	\$3,245	\$600,000	\$6,490
Colombia	Grupo Andino	\$42	\$16	\$15,659	\$199	\$1,037	\$282	\$292	\$381	\$303	\$3	\$1,330	\$600,000	\$2,660
Costa Rica	Centroamérica	\$194	\$31	\$15,659	\$194	\$954	\$357	\$278	\$468	\$321	\$3	\$1,236	\$600,000	\$2,472
Dominican Republic	Centroamérica	\$295	\$50	\$15,659	\$194	\$954	\$357	\$404	\$654	\$277	\$3	\$1,236	\$600,000	\$2,472
Ecuador	Grupo Andino	\$42	\$16	\$15,659	\$199	\$1,037	\$287	\$292	\$381	\$303	\$3	\$1,676	\$600,000	\$3,352
El Salvador	Centroamérica	\$194	\$31	\$15,659	\$194	\$954	\$357	\$278	\$468	\$321	\$3	\$1,068	\$600,000	\$2,136
Guatemala	Centroamérica	\$194	\$31	\$15,659	\$194	\$954	\$357	\$278	\$468	\$321	\$3	\$1,068	\$600,000	\$2,136
Guyana	Caribe	\$325	\$36	\$15,659	\$185	\$913	\$353	\$472	\$580	\$425	\$4	\$1,204	\$600,000	\$2,408
Haiti	Centroamérica	\$194	\$31	\$15,659	\$194	\$954	\$357	\$278	\$468	\$321	\$3	\$227	\$600,000	\$454

country	subregion	Price Satellite Connection Monthly	Price Satellite Connection Monthly	Price for expansion of 1km of fiber	Price for the Access Point	Price for the Firewall	Price for the Nobreak	Price for Tablet	Price for Laptop	Price for Cloudbook	Price for hiring a platform for students	Price for the Teacher Salary	Price for designing the course for teachers	Price for hiring a teacher trainer
Honduras	Centroamérica	\$194	\$31	\$15,659	\$194	\$954	\$357	\$278	\$468	\$321	\$3	\$1,068	\$600,000	\$2,136
Jamaica	Caribe	\$325	\$36	\$15,659	\$185	\$913	\$353	\$472	\$580	\$425	\$4	\$1,204	\$600,000	\$2,408
Mexico	Centroamérica	\$93	\$13	\$15,659	\$194	\$954	\$357	\$230	\$376	\$349	\$3	\$1,509	\$600,000	\$3,018
Nicaragua	Centroamérica	\$194	\$31	\$15,659	\$194	\$954	\$357	\$278	\$468	\$321	\$3	\$247	\$600,000	\$494
Panama	Centroamérica	\$194	\$31	\$15,659	\$194	\$954	\$357	\$278	\$468	\$321	\$4	\$2,200	\$600,000	\$4,400
Paraguay	Cono Sur	\$69	\$16	\$15,659	\$157	\$825	\$229	\$264	\$304	\$184	\$3	\$1,545	\$600,000	\$3,089
Peru	Grupo Andino	\$42	\$16	\$15,659	\$199	\$1,037	\$287	\$292	\$381	\$303	\$3	\$1,251	\$600,000	\$2,502
Surinam	Caribe	\$325	\$36	\$15,659	\$185	\$913	\$353	\$472	\$580	\$425	\$4	\$1,204	\$600,000	\$2,408
Trinidad and Tobago	Caribe	\$325	\$36	\$15,659	\$185	\$913	\$353	\$472	\$580	\$425	\$4	\$1,204	\$600,000	\$2,408
Uruguay	Cono Sur	\$98	\$18	\$15,659	\$194	\$960	\$250	\$447	\$680	\$270	\$4	\$1,367	\$600,000	\$2,734
Venezuela	Grupo Andino	\$42	\$16	\$15,659	\$199	\$1,037	\$287	\$292	\$381	\$303	\$3	\$10	\$600,000	\$20

Observations: In the calculator, the prices are dynamic and they can be updated.

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