EdTech Hub

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HELPDESK RESPONSE 32

Cost-Effectiveness and EdTech

Considerations and case studies

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Notes

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This document was produced in response to a joint request from FCDO and World Bank to the EdTech Hub Helpdesk in January 2021. It can be used as a guide for decision-makers in and out of government to examine the cost-effectiveness of EdTech programmes and products more closely. This document does *not* serve as a comprehensive or exhaustive review of all tech-enabled education initiatives. It is a foundational piece for future EdTech Hub work on cost-effectiveness.

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Abbreviations and acronyms

CAL	Computer-assisted learning
CAPEX	Capital expenditures
EGMA	Early Grade Mathematics Assessment
EGRA	Early Grade Reading Assessment
FCDO	Foreign, Commonwealth and Development Office, UK Government
GPS	Global positioning system
HICs	High-income countries
ICT	Information and communications technology
IRC	International Rescue Committee
LAYS	Learning-Adjusted Years of Schooling
LMICs	Low- and middle-income countries
OPEX	Operating expenses
PISA	Programme for International Student Assessment
PRIMR	Primary Math and Reading (Initiative in Kenya)
RCT	Randomised Control Trial
SIEF	Strategic Impact Evaluation Fund
TCO	Total cost of ownership
TIMSS	Trends in International Mathematics and Science Study
TPD	Teacher professional development

Executive summary

Conducting cost-effectiveness analysis for an initiative involves calculating a ratio of costs to impact that can be benchmarked against other ratios. This methodology can be used to compare EdTech initiatives and identify common themes that contribute to high cost-effectiveness. Analysing the cost-effectiveness of EdTech is all the more important in light of existing gaps in our knowledge of what is most and least effective.

The answer to the question 'What is cost-effective EdTech?' is highly nuanced, as it depends on the choice of the initiative, its design, implementation, intended audience, how the local context is addressed and the time frame during which cost-effectiveness is assessed. Given these complexities, we encourage decision-makers to walk through the guiding questions in Table 1 prior to engaging in cost-effectiveness analysis for an EdTech initiative.

Table 1. *Guiding questions on cost-effectiveness and EdTech.*

Category	Question(s)
Costs	How will the initiative's overall costs be calculated? Does this include both initial and recurrent costs of the initiative? Have the direct and indirect costs of EdTech (e.g., license fees, cost of repairing hardware, cost of parental engagement) been included? Who is implementing the initiative and how does this affect the cost of implementation?
Effectiveness	What metrics should be used to calculate the effectiveness of the initiative (e.g., literacy and numeracy outcomes using Early Grade Mathematics Assessment and Early Grade Reading Assessment)? What metrics can be utilised to capture other dimensions of education outside of learning, such as learner participation and retention? Is there an opportunity to use Learning-Adjusted Years of Schooling (LAYS)?
Equity	For whom is the initiative cost-effective? Does the initiative prioritise equity and reaching the most marginalised? If not, what is the rationale behind this decision?

Timing	How does the initiative balance between designing for the present and the future? Do you anticipate a learning curve for new technology that is introduced to a context? What is the time frame most appropriate for conducting cost-effectiveness analysis? What costs would or would not be captured, or would change, depending on the time frame you choose?
Other	What alternative initiatives have been considered? Considering elements of stakeholder buy-in, political will, and available funding, will the initiative be sustainable?

We compiled select case studies that examine how EdTech was used in cost-effective and less cost-effective ways on:

1. structured pedagogy and teacher coaching;
2. low-tech messaging to support learners, parents and caregivers;
3. self-led learning with potential for personalisation and adaptation.

Lessons learned from these case studies include:

- In many cases, how the technology is implemented and integrated into an education system has greater implications for effectiveness than what technology is used. Further, an EdTech initiative that generates significant learning gains may not be cost-effective when compared to non-tech, low-tech, or other tech-based initiatives that are less expensive.
- While evidence suggests that projects that solely provide access to technology are frequently not effective or cost-effective, these initiatives can still hold great value as the building blocks for other, future EdTech projects that will contribute to learning.
- EdTech initiatives that allocate digital devices to teachers, coaches, or groups of learners, rather than using a 1:1 learner-to-device ratio, have lower costs per child. This can increase an initiative's cost-effectiveness if carefully designed.

- However, decision-makers should also take into account an initiative's effectiveness alongside cost-effectiveness. This can help avoid the sole prioritisation of EdTech investments that are extremely cheap and reach large numbers of learners but have limited impact on individual learners.
- Complementary investments that are likely to enhance the cost-effectiveness of an EdTech initiative include the local technological infrastructure and device availability; teacher professional development; and a country's education policy, capacity, and data systems.

Understanding what is cost-effective for EdTech depends on the availability of data, frameworks, and tools to capture costs and impact. Governments, donors, and other partners can leverage the recent proliferation of EdTech initiatives in the wake of Covid-19 to generate more evidence on the use of EdTech. Ultimately, this information can be used to realise the full potential of EdTech to support learning around the globe.

1. Defining cost-effectiveness

1.1. Cost-effectiveness as a means of comparison

In the education sector, cost-effectiveness analysis is used to calculate a ratio of costs to impact for a specific initiative (e.g., average cost per learner versus amount gained on the learning outcome), that can then be compared to and benchmarked against others (↑Kremer et al., 2013; ↑Sabates, et al., 2018). As the success of education initiatives relies on multiple contextual factors, the purpose of cost-effectiveness analysis is not to single out one initiative as 'the best', or universally the most impactful (↑Walls, et al., 2020). It instead enables users to identify key drivers of high cost-effectiveness, assess opportunity costs and understand the range of trade-offs across initiatives. Findings from cost-effectiveness analysis can inform how to compare, evaluate, and prioritise different initiatives to increase value for money.

Figure 1. *All about value for money (↑EdTech Hub, 2020; ↑Jackson, 2012; ↑Walls, et al., 2020).*

Cost-effectiveness and value for money are interconnected concepts. Value for money is defined as the balance between the 5 E's of effectiveness, equity, efficiency, economy, and environment:

- **Effectiveness**: What is the impact achieved compared to the cost of inputs?
- **Equity**: How are the most marginalised being reached?
- **Efficiency**: How many outputs are achieved compared to the cost of inputs?
- **Economy**: How are major inputs being managed to reduce costs?
- **Environment:** What is the impact on the planet?

An additional aspect of value for money that falls outside of the 5 E's is sustainability. Given the multifaceted nature of value for money, there are often trade-offs between each of the E's and sustainability that a decision-maker should consider. For example, a somewhat inefficient and high-cost programme with sustainable outcomes may offer a better value for money than a low-cost programme that is highly efficient.

While we acknowledge the usefulness of approaching education and EdTech initiatives from the lens of the 5 E's, throughout this paper we will utilise the term 'cost-effectiveness' rather than 'value for money'. There may be some continued debate about whether these two terms are, in fact, the same. However, regardless of the terms used, we ultimately seek to unpack how education decision-makers can engage with the topic of cost-effectiveness for EdTech initiatives in this brief.

1.2. 'Cost' and 'effectiveness'

The two components that make up cost-effectiveness analysis — costs and impact — require robust data and common metrics (↑Global Education Evidence Advisory Panel, 2020). For costs, this information can be categorised in different ways, such as capital expenditures (CAPEX) versus operating expenses (OPEX) and financial versus economic costs. Capital expenditures are one-time, lump-sum amounts that are used to create new initiatives and projects. Operating expenses are recurrent costs necessary for the day-to-day functioning of a project and may include labour, electricity, materials, etc. The benefits of capital expenditures are realised in the future, while the benefits for operational expenditures are realised in the current year. Using CAPEX and OPEX can help identify implications for short term and long term planning (↑Morrell, 2017).

Financial costs are those that are paid for or contributed, such as project expenditures (↑Ross, 2018). Economic costs, as the name implies, are costs to the overall economy and include opportunity costs, defined as "the value of a good or service in its best alternative use" (↑Walls et al., 2020). For instance, certain EdTech initiatives that require parental and caregiver support have opportunity costs for the time that these individuals allocate to the initiative. If there are price controls or regulations, the opportunity cost is the cost if there were no such regulation. In general, looking across financial and economic costs is important when considering who finances and implements an initiative. Private investors tend to use only financial costs, while governments making public policy choices typically use economic costs. The party that implements an initiative is closely tied to different cost structures and systems, which greatly impacts the overall costs.

Cost-effectiveness analysis also benefits from rigorous assessments of programme impact using experimental or quasi-experimental methods (↑Walls et al., 2020). In addition to the use of learning outcomes, other dimensions can be used to measure impact including but not limited to: learner enrolment, retention, participation, interest, and socio-emotional outcomes. In some cases, Learning-Adjusted Years of School (LAYS), a global learning metric that enables comparisons across country contexts, can be used to enhance one's understanding of programme impact (↑World Bank, 2018).

Several resources that can be used to measure costs and impact are summarised in the Appendix of this brief, covering available guidance on cost capture (i.e., the collection of data to be utilised in a costing analysis) and measuring impact.

1.3. Other cost analysis methodologies

Based on the objectives of a study, an education decision-maker may opt to use one or more cost analysis approaches, including cost-effectiveness analysis. Prior to conducting the study, the questions that the cost analysis should answer should be defined to inform the chosen methodologies, which may include the following:

1. **Cost-economy analysis** examines the total cost of a programme, its sustainability, and the cost of scaling up. A cost-economy analysis answers the question: 'What did it cost to implement the programme?'
2. **Cost-efficiency analysis** compares the costs of a programme with the outputs from the programme. A cost-efficiency analysis answers the question: 'How much did the programme cost per output delivered?'
3. **Cost-benefit or rate-of-return analysis** compares the total costs (including indirect and opportunity costs) of a programme to the value of the benefits derived from that programme. Benefits are monetised and compared to project costs. A cost-benefit or rate-of-return analysis answers the question: 'Was this programme 'worth it'?'
4. **Cost-effectiveness analysis** compares the costs of a programme with the outcomes from the programme. This approach is relevant for projects where monetising outcomes is not appropriate or even possible. A cost-effectiveness analysis answers the question: 'How much did the programme cost per outcome delivered?' (↑Jackson, 2012; ↑Walls et al., 2020).

2. Key considerations when thinking about cost-effectiveness

This section is intended to highlight considerations that may often be overlooked when thinking about cost-effectiveness. However, these considerations are also likely to have a substantial impact on the outcomes of cost-effectiveness analysis with implications for decision-making around current and future education initiatives. We cover six high-level considerations for decision-makers engaging with cost-effectiveness and EdTech below:

- Define EdTech costs carefully;
- Compare impact across interventions;
- Promote intersections of equity and cost-effectiveness;
- Conduct analysis in the short and long term;
- Design for both the present and the future;
- Don't forget about sustainability and financing.

2.1. Define EdTech costs carefully

Decision-makers can act as powerful advocates of cost capture in education, supporting future evidence-informed decisions. This is critical as cost data is often not disaggregated, calculated incorrectly, or missing (↑Walls et al., 2020; ↑World Bank & International Rescue Committee, 2019). Whenever possible when calculating cost-effectiveness, costs should be captured in real time and from multiple sources to increase transparency and accuracy (↑World Bank & International Rescue Committee, 2019). Unless data is collected accurately at the source, comparisons across initiatives are problematic.

As EdTech initiatives rarely include the provision of hardware without any wrap-around services or support, the process of cost capture differs from other education initiatives. Costs pertaining to EdTech frequently are incurred even after the lifetime of an implemented project, due to hardware maintenance, tech support, etc. Using the total cost of ownership (TCO), which encompasses both the direct and indirect costs of an initiative, is thus integral. TCO can include the initial investment, ongoing costs for the technology environment, as well as amortisation or depreciation of assets over time (↑edWeb, 2019). Recognising that in many cases, assets may not actually be 'owned', but rather rented, leased, or subscribed to, TCO should also account for costs of operation. As an example of the potential complexity of calculating the TCO, a recent UNICEF report examined the cost drivers of the online

Learning Passport portal ((↑Learning Passport, no date).[1] The authors noted that while the portal itself is free for all to access, additional costs related to content contextualisation, staff training, and hardware and infrastructure to allow for offline usage may be incurred (↑Guglielmi et al., 2021).

Considering the TCO will help decision-makers plan for the long term sustainability and continuity of the project, from its onset. While calculating cost per child is rarely simple due to its initiative-specific nature, it provides key information to support one's decision to invest in or scale an initiative.

Figure 2. *Costing EdTech Hub sandboxes with Jusoor and onebillion.*

EdTech Hub engages in various 'sandboxes' around the world to support the implementation of EdTech initiatives and generate new evidence on what works (↑Simpson, 2020).[2] In 2020, we worked with Jusoor, one of our sandbox partners, to understand effective approaches to WhatsApp messaging for refugee children in Lebanon. Based on guiding principles from the ↑World Bank & International Rescue Committee (2019), we assessed the cost of the existing implementation model, as well as projected costs for alternatives.

The team identified the highest costs in the projected model were teacher salaries and data, which were 27% and 39% of the projected budget, respectively. Based on the cost model, it is likely that there will be a drop in cost per year, per child (from GBP 207 to GBP 192) when the programme is delivered at scale for 300,000 children (↑Tutunji et al., 2020). The team is exploring ways to cut down data costs to further reduce cost per child, while also ensuring that this does not compromise the effectiveness of the intervention.

In 2021, the Hub worked with the organisation onebillion to develop a plan for scaling the Unlocking Talent project[3] with the Malawian Ministry of Education (↑Unlocking Talent, 2021). As part of the sandbox, the Hub assessed various implementation models for the usage of onetab[4] devices at scale in the classroom and at home (↑onebillion, 2020). Findings supported that hardware lifetime or the number of years a tablet can function, in addition to the ratio of tablets to learners, had the largest influence on costs.

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[1] You can read more about the Learning Passport portal here: https://www.learningpassport.org/

[2] You can read more about the Hub's sandbox approach here: https://edtechhub.org/2020/01/28/sandboxes-our-approach-to-systemic-experimentation/

[3] You can learn more about the Unlocking Talent project here: https://unlockingtalent.org/

[4] onetab tablets deliver numeracy and literacy lessons to learners. You can learn more about onetab here: https://onebillion.org/onetab/

Decision-makers also should be aware of costs that may be overlooked for EdTech initiatives or products. The 'freemium' business model[5] used by many EdTech companies adds further complexity to the process of deciphering the cost of a product. Recurrent, often hidden EdTech costs may include, but not be limited to:

- Costs of network equipment (routers, switches, wireless access points) and server hardware (hardware upgrades or spare parts);
- Cost of repairing or replacing broken hardware;
- License fees for any curriculum used;
- Software costs;
- Costs of vendor or technology lock-in (if a preferred alternative is available but cannot be pursued);
- Costs of piloting and testing software or other innovations through 'test beds';
- Energy usage costs;
- Connectivity costs;
- Required investments in school building infrastructure to increase security and securely house expensive new equipment;
- Salaries of support team members;
- Costs associated with parental engagement;
- Indirect labour costs as users work individually or with others to resolve device, systems, and network issues. For instance, teachers who dedicate time to addressing these issues may spend less time on direct instruction (↑Blagrave, 2020; ↑Consortium for School Networking, 2016; ↑Tauson & Stannard, 2018; ↑Warschauer & Ames, 2010).

2.2. Compare impact across initiatives

Cost-effectiveness analysis is valuable because it allows decision-makers to make comparisons across initiatives. Effective comparison requires that impacts of the assessed initiatives are generated using the same methodologies (↑Walls et al., 2020). There are a number of methodologies and

[5] The freemium business model offers basic features to users at no cost. In some cases, a company charges a premium for additional features or only offers a free trial of its features for a certain length of time (↑Levine, 2019). In some cases, the use of such 'free' services can lead to data privacy issues and compromise a user's important information (↑Ferry, 2018).

approaches that can be used, to be selected by a decision-maker based on the programme's anticipated impacts.

One metric used to measure learning outcomes is Learning-Adjusted Years of Schooling (LAYS), which takes both the quality and quantity of education into account. This metric uses other measures of learning, such as Trends in International Mathematics and Science Study (TIMSS) or Programme for International Student Assessment (PISA), to express education gains from different contexts or projects in terms of equivalent school years, and then adjusts this value to account for the quality of education (relative to a benchmark country or to an absolute standard; ↑Filmer et al., 2018). This gives LAYS an advantage over alternatives that may only consider the quantity of schooling. In addition, as LAYS is expressed in terms of years of quality schooling, it may be easier to interpret than measures expressed in terms of standard deviations of learning assessments.

It should be noted that LAYS does not capture other forms of learning (e.g., socio-emotional learning) or secondary benefits of education (e.g., reduced child marriage and drop-out, democratic participation, labour market outcomes; ↑Crawfurd et al., 2019). This limitation is important to consider as it affects what assumptions are implicitly made regarding the broader purpose and meaning of 'education'. Approaches that take into account labour market outcomes, income, or life satisfaction would all reflect different perspectives of what it means to educate young people in a community. For example, ↑Pradhan et al. (2018) consider the returns to education in terms of wages, employment, and occupation in India. The International Rescue Committee conducted a randomised controlled trial (RCT) in the Democratic Republic of Congo that examined not only literacy and numeracy outcomes but also learner socio-emotional learning and teacher well-being (↑Aber et al., 2015).

While these studies did not extend to analysing cost-effectiveness, they do highlight the utility of considering outcomes other than academic test scores. Section 2.4 in the Appendix summarises a resource that provides guidance on how to measure such alternative educational outcomes. However, regardless of which learning outcome is selected, comparable tests across countries or projects would still be required to capture these outcomes as part of cost-effectiveness calculations.

2.3. Promote intersections of equity and cost-effectiveness

While engaging in conversations around cost-effectiveness, the target audience of the initiative should be a key focus. By doing so, decision-makers can ensure that the intersections between cost-effectiveness and equity are not overlooked. In many cases, the most marginalised learners are more expensive or difficult to reach. What's more, marginalised learners may also require different initiatives to meet their unique needs (↑Global Partnership for Education, 2014). This means that some EdTech initiatives characterised as cost-effective may exclude learners with limited or no access to technology, or fail to meet their unique needs. It is thus crucial to consider the broader vision of delivering quality education for all children, including the most marginalised, asking the question of whose value for money is being achieved (↑Singal, et al., 2017).[6]

At the same time, balancing equity and cost-effectiveness need not necessarily be a zero-sum game. In many cases, focusing on equitable learning outcomes for the most marginalised can also enhance the educational experiences of other learners. This may happen through increased diversity in classroom experiences, as well as long term changes at the systems level that make education systems more responsive to the needs of all learners, not only those traditionally considered 'marginalised' (↑Singal, et al., 2017). In this way, focusing on equity can improve learning outcomes for all learners, pointing to a new paradigm of how to understand and promote equity alongside cost-effectiveness. Rather than positioning these two factors as juxtaposed priorities, decision-makers must mainstream equity in calculations of cost-effectiveness itself. Existing methodologies that adjust for equity can be built upon to enhance our understanding of cost-effectiveness across initiatives (see Figure 3).

Figure 3. *Reaching marginalised girls in Tanzania (↑Sabates et al., 2018).*

A cost-effectiveness analysis was conducted for Camfed's programme in Tanzania, which seeks to reach marginalised girls at the secondary education level. The researchers included an equity weight in the cost-effectiveness ratio that differentiated between the two groups of learners that benefited from the programme: those who received financial support (marginalised girls), as well as those who attended Camfed-supported schools (all learners). The weighted cost-effectiveness ratio was then calculated based on both values. Importantly, the separate cost-effectiveness calculations and disaggregated data facilitated cross-programme comparisons that can contribute to conversations on equity by measuring cost-effectiveness specifically for marginalised populations.

The researchers noted that "comparisons with other interventions in Africa show that Camfed's programme has been able to attain similar

[6] Benefit incidence analysis may be a helpful tool to understand equity vis-a-vis cost and resource allocation, including across levels of schooling and wealth quintile groups. For more information, see https://www.unicef.org/reports/investment-case-education-and-equity.

cost-effectiveness outcomes relative to ones that have not included the aim of reaching the most marginalised." High cost-effectiveness was achieved while still reaching the most marginalised, as the highly vulnerable students only comprised a portion (18%) of the overall cohort. In addition, targeting the most marginalised with a focus on equity and inclusion ensured that all learners in Camfed-supported schools were reached.

2.4. Conduct analysis in the short and long term

There is no universal recommendation as to when cost-effectiveness analysis should occur. Rather, the timing should be aligned with decision points throughout the programme cycle that can be informed by data on cost-effectiveness (e.g., deciding whether or not to scale up a programme, or deciding which of two programmes will be funded). One approach could be to measure cost-effectiveness at different stages of scale-up. Regardless of when exactly the analysis is conducted, it should be planned from the start of the project. Systems for data collection should be established to ensure that data can be collected in real time (↑World Bank & International Rescue Committee, 2019).

Figure 4. *Scaling up an EdTech pilot (↑Walls et al., 2020).*

Education decision-makers should keep in mind that estimates from cost-effectiveness analysis are based on a specific context and scope. The key question to answer is, 'What is the impact of this programme, for whom, at what cost (and who bears these costs), under what context?' This question can help identify changes in cost and impact associated with scaling an EdTech pilot. If a pilot programme has missing data on costs and / or impact, further analysis would be recommended to better understand the implications of scaling up the initiative prior to widespread implementation.

For example, the Makhalidwe Athu project[7] in Zambia was a nine-month pilot that provided reading materials and activities to parents and caregivers to support children's learning (↑Creative Association International, 2021). The project was found to have a significant effect on learner reading fluency and comprehension. Initial cost analysis estimated the cost per child (including development and implementation costs) to be

[7] You can read more about the Makhalidwe Athu initiative here: https://makhalidweathu.com/

USD 700. Following the impact evaluation results, additional analysis was conducted to better understand the costs of scaling up the pilot nationally.

The analysis highlighted that development costs would be lower, given that the intervention was already developed. Final scale-up costs per child were estimated to be between USD 20.10 and 21.60 with economies of scale. Lastly, the project was mostly piloted with learners in rural areas. Given expected differences in cell phone ownership rates, the fixed costs of the programme were expected to be lower when scaled up across the country.

When determining the timing of cost-effectiveness analysis, a decision-maker should be aware that both overall and component costs may change over time. This is especially key in cases where individual component costs do not move in the same direction as overall costs or other component costs. For example, hardware and infrastructure costs can require large, upfront investments. However, they tend to decrease over the years (with a spike in costs after a few years due to the need for replacement or repair of devices). In particular, the scale of the project may greatly affect component costs and cost structure.

Further, any time a new technology is introduced in a context, a learning curve should be expected. An EdTech initiative may initially not be cost-effective, but continue to grow in value as teachers, learners, and others become more accustomed to it. In other cases, the effects of an EdTech initiative may plateau or decrease over time, due to waning novelty of the technology or the perception of its value to support learning within a school or community. Conducting a cost-effectiveness analysis too early in the initiative's lifetime may stymie innovation and risk preemptively labelling an initiative as 'not cost-effective', when in fact the true value for money has yet to be realised. It is critical to discuss at the start of an initiative when the impacts are expected to be realised, and determine the timing of cost-effectiveness analyses accordingly (↑Jackson, 2012). We would recommend that cost-effectiveness analysis for an initiative be conducted in both the short term and long term.

2.5. Design for both the present and the future

Changing cost dynamics in the sector signal that what is cost-effective now may not be cost-effective in the future and vice versa. Given the proliferation of personal, especially mobile, devices around the world, digital initiatives are likely to become cheaper in the near future (↑Booton, 2016). As a result, education decision-makers need to balance between designing for the present and the future. Within a specific country, this might look like making simultaneous investments in low-cost, low-tech initiatives to reach marginalised learners now, as well as more expensive, infrastructural investments for future planning.

During school closures caused by Covid-19, 68% of countries implemented multi-modal approaches to learning, across digital and non-digital channels (↑Dreesen et al., 2020). The combination of multiple channels helped to reach marginalised learners with limited access to devices, while also providing an opportunity for countries to invest in EdTech that could be used beyond school closures. For example, the Jordanian Ministry of Education used television to broadcast lessons twice a day and also launched an educational portal with free lessons (↑World Bank, 2020). However, in Jordan and elsewhere, equitable access to digital, online platforms continues to be a challenge (↑UNHCR et al., 2020). Barriers include families' inability to afford devices and enough data to fully support their children's online learning. To build upon the portal's usability post-Covid-19, a decision-maker might consider adapting the platform to enable offline functionality and configuring it for both school-based and out-of-school use.

In general, we would caution decision-makers against solely investing in EdTech in high-resource contexts, where enabling factors such as pre-existing connectivity and devices drive down the cost of tech-enabled initiatives. While these efforts may be cost-effective, equity must also be taken into account, so as not to widen the intra-country digital divide. This may also be the case for donors working to assess investments across LMICs and HICs on a global scale. As decision-makers design for the future, investments complementary to EdTech, such as teacher professional development initiatives, must not be overlooked (see Section 4).

EdTech holds potential to combat the global learning crisis through increasingly individualised and results-oriented learning that takes place in and out of the classroom (↑Vegas et al., 2019). Such opportunities are all the more important in a post-Covid world, given the high likelihood of future disruptions to learning that may preclude face-to-face and non-tech initiatives. ↑HolonIQ (2020), a platform focused on global education market trends, predicts that "a short-term surge in EdTech spending brought on by Covid-19 is expected to re-calibrate to a longer-term integration of digital technologies and transition to much higher adoption of online education over the coming years." Importantly, this transition is expected to include large investments in 'infrastructure catch-up' to oversee learning, data, and administration (↑HolonIQ, 2020).

2.6. Don't forget about sustainability and financing

Additional factors pertaining to the sustainability of an initiative, such as stakeholder buy-in, political will and financing, can also direct decisions on whether to invest in relevant, cost-effective EdTech initiatives. An analysis of stakeholder interests in influencing EdTech policies and the consequences of those interests can inform the development of initiatives within a certain context. For example, without support from key stakeholders within and outside of a country's government, a cost-effective initiative is unlikely to be implemented and scaled successfully. Other incentives, relationships, capacity, and power dynamics may also be important to consider (↑Pellini et al., 2021).

Regarding financing, the effects of the Covid-19 pandemic have continued to impact domestic education budgets, household budgets, and aid allocations (↑Read, 2020). Two-thirds of LICs and LMICs have cut their public education budgets since the onset of the Covid-19 pandemic (↑World Bank, 2021).[8] Further, ↑UNESCO (2020) estimated that aid to education may not return to 2018 levels until 2025–2026. As a result, decision-makers should be cognisant of weighing what is economically advantageous against what can actually be financed. In some cases, costly investments that are cost-effective and yield large learning gains simply may not be feasible due to budgetary constraints (↑Read, 2020).[9]

[8] However, according to the 2021 Education Finance Watch, the budget cuts for LICs and LMICs have been relatively small (3.6%; ↑World Bank & UNESCO, 2021).
[9] For more information on options for financing education in the wake of Covid-19, you can refer to the Save Our Future background paper 7: https://saveourfuture.world/wp-content/uploads/2020/12/COVID-19-and-Options-for-Financing-Education_SOF_BP7.pdf

3. Cost-effective EdTech investments

This section first provides a high-level summary of what we know so far about cost-effective EdTech. It then examines three EdTech case studies across low-resource and high-resource contexts that provide lessons learned on cost-effectiveness.

3.1. What we know so far

There is limited rigorous evidence to date on what effective or cost-effective EdTech looks like. Further, existing research points to a mixed picture on the effectiveness of EdTech (↑Hennessy, et al., 2020). However, the general consensus is that *how* education technology is used is often just as, if not more, important as *what* education technology is used. For example, a study by ↑Barrera-Osorio & Linden (2009) examined the Computadores para Educar (Computers for Education) programme in Colombia. Despite increasing the number of computers and learners' use of computers across schools, little to no effect on learning outcomes was observed. The researchers identified the lack of integration of computers into the curriculum used by teachers as a key flaw in the programme design. Other examples of stand-alone inputs without careful consideration of the local context and learning environment point to similar findings (↑Global Education Evidence Advisory Panel, 2020).

Two recently published papers also contribute to the existing knowledge base on cost-effectiveness and EdTech and warrant further consideration. First, a systematic review of EdTech in LMICs categorised tech-enabled interventions within four thematic areas:

1. Access to technology;
2. Technology-enabled behavioural interventions;
3. Improvements to instruction;
4. Self-led learning.

Based on an analysis of 67 studies that were grouped within the four areas, technology-enabled behavioural interventions, improvements to instruction, and self-led learning were found to be the most promising areas for cost-effective approaches (↑Rodriguez-Segura, 2020). However, it was noted that these categories were not exclusive and often overlapped with each other.

While access to technology was indicated to have low cost-effectiveness, it is evident that many EdTech initiatives combine the provision of technology with other programmatic aspects such as improvements to instruction or self-led learning. In some cases, investing in devices and enabling infrastructure, while initially having little to no direct impact on learning, may pave the way for effects that grow over time or for other initiatives that contribute largely to children's learning (↑Kho et al., 2018; ↑Rodriguez-Segura, 2020; ↑Seo, 2017). ↑Rodriguez-Segura (2020) states:

> **"Interventions that facilitate access to technology are a first and necessary step to implement other EdTech solutions like educational software, especially in many remote and deprived areas."**

Capital investments that allow for 'infrastructure catch-up' post-Covid, as mentioned in Section 2.5, can act as the building blocks for further innovation and future benefits in education.

Second, a ↑Global Education Evidence Advisory Panel (2020) report on cost-effective approaches to improving global learning sorted initiatives into four tiers of cost-effectiveness. Based on available, rigorous evaluation evidence, some of the approaches identified as cost-effective included:

1. Giving information on the benefits, costs, and quality of education;
2. Structured lesson plans with linked materials and ongoing teacher monitoring and training;
3. Targeting teaching instruction by learning level, not grade (in or out of school);
4. Using software that adapts to the learning level of the child (where hardware is already available in schools);
5. Focusing on pre-primary education (ages 3–5).

Each of the approaches listed above was highlighted as cost-effective in the report (designated as a 'Great Buy' or 'Good Buy').[10]

3.2. Introduction to case studies

The initiatives included in this section serve as illustrative examples of what cost-effective uses of EdTech look like (or do not look like) in differently resourced contexts. Examples were selected based on:

[10] An analysis by ↑Lewin (2020) noted that there may be additional cost-effective approaches not included in the report that governments have implemented without external financing. In some cases, these initiatives did not collect cost data and / or conduct an RCT-based evaluation, and thus were excluded from the report.

1. their focus on EdTech;
2. alignment to one or more of EdTech thematic areas / education intervention categories (see Table 2);
3. relevant lessons learned on cost-effectiveness.

Table 2. *EdTech case studies across low-resource and high-resource contexts.*

Case study	Description	Thematic area (↑Rodriguez-Segura, 2020)	Intervention category (↑Global Education Evidence Advisory Panel, 2020)
1	Enhancing structured pedagogy through technology-enabled components for learners, teachers, and instructional supervisors (↑Piper et al., 2016)	Access to technology Improvements to instruction	Structured lesson plans with linked materials and ongoing teacher monitoring and training
2	Reaching learners, parents and caregivers through targeted messaging via phone calls and SMS in Botswana (↑Angrist et al., 2020), and via a personalised SMS approach in the U.S. (↑Doss, et al., 2017)	Technology-enabled behavioural interventions Improvements to instruction	Giving information on the benefits, costs, and quality of education Targeting teaching instruction by learning level, not grade (in or out of school) Pre-primary education (ages 3–5)
3	Comparing two computer-assisted learning programmes — one that tailors content and processes to a child's learning level (↑Muralidharan et al., 2018) and another that does not take a personalised approach (↑Ma, et al., 2020)	Self-led learning	Using software that adapts to the learning level of the child (where hardware is already available in schools)

We would caution the reader against applying broad generalisations from the examples provided to their own work without first examining the initiative location, intended audience, and enabling environmental factors. Rather than comparing initiatives that utilise the same EdTech modalities (e.g., one tablet-based initiative with another tablet-based initiative), we recommend comparing various initiatives in a given context based on their overarching objective (e.g., reaching parents to support their children's learning). Again, the 'how' of EdTech is much more important than the 'what' (↑EdTech Hub, 2021).[11]

3.3. Case study 1: Enhancing structured pedagogy through technology

Structured pedagogy refers to an aligned and cohesive package of support tools (e.g., learner materials, teacher training) used to improve classroom instruction (↑better purpose, 2020). One example of a structured pedagogy initiative is the Kenya Primary Math and Reading (PRIMR) programme, which was implemented in 2012 and provided textbooks for learners, teachers' guides that were aligned to the textbooks, regular teacher training and support, and feedback from instructional supervisors who conducted regular classroom visits. Significant effects on literacy outcomes in English and Kiswahili were observed from this base PRIMR programme, which did not employ any technology (↑Piper et al., 2016).

A follow-up study examined three supplementary, tech-enabled interventions that supplied e-readers for learners, tablets for teachers, and tablets for instructional supervisors who worked closely with teachers. Table 3 contains a summary of the estimated cost per child for each intervention.

Table 3. *Cost per child for PRIMR tech-enabled interventions (↑Piper, et al., 2016).*

Intervention	Base cost	ICT cost	Total cost*
1 e-readers for learners	USD 4.56	USD 40	USD 44.56
2 tablets for teachers	USD 4.56	USD 3	USD 7.56
3 tablets for instructional supervisors	USD 4.56	USD 0.10	USD 4.66

*The total cost, consisting of base and ICT costs, is likely to be recurring, given ongoing maintenance and replacement. The base cost included: textbooks, teachers' guides, teacher training, classroom observations, and training for instructional supervisors.

[11] That said, low-tech modalities such as radio, television, SMS messaging, and virtual learning environments (VLEs) that work both offline and online are often the most viable options for reaching marginalised learners in low-resource contexts. You can access EdTech Hub rapid evidence reviews on these topics here: https://edtechhub.org/research/#synthesis

Positive impacts on literacy outcomes were reported from all three intervention groups. However, aside from the intervention that provided tablets to instructional supervisors, the other tech-enabled interventions were not found to be more cost-effective than the base programme. The researchers concluded that: "when costs are considered, there are non-ICT interventions that could have larger impacts on learning outcomes with lower cost."

Two important lessons stem from the ↑Piper, et al. (2016) study. First, it is important to compare the cost-effectiveness of an EdTech initiative to non-tech, low-tech as well as other tech-based initiatives.[12] While select initiatives may produce learning gains, such results may be comparable to non-tech or low-tech initiatives that are usually less expensive; this is even more the case in situations with no or unreliable electricity supply. Second, measuring cost per child means that EdTech initiatives that allocate the technology to teachers, coaches, or groups of learners (rather than individual learners) are often more cost-effective. However, learner initiatives, including those with a 1:1 learner-to-device ratio, should not be discounted if a high impact on learning is demonstrated.

The PRIMR programme served as a precursor to the Tusome intervention implemented in 2014 that encompassed the provision of textbooks, teachers' guides, and teacher training on a national scale. Based on the findings from the PRIMR study, instructional supervisors received tablets to record classroom observations; the tablets also had global positioning system (GPS) functionality to verify the location of the supervisor (↑Piper et al., 2018). ↑Angrist et al. (2020) supported findings that the Tusome intervention was both effective (1.04 LAYS) and cost-effective (4.90 LAYS per USD 100), compared to 150 other education interventions across 46 LMICs.

3.4. Case study 2: Reaching learners, parents and caregivers through targeted messaging

There are several messaging initiatives for parents and caregivers that report learning gains with low cost per child and have potential to scale widely. Low-tech messaging can be used to support parental instruction, delivering information to support a child's learning at home and at school. In Botswana, ↑Angrist et al. (2020) piloted two low-tech interventions for primary learners during Covid-19-related school closures. Learners were randomly assigned to the control group, the SMS only group (families received weekly numeracy problems via text), or the phone and SMS group (in addition to the text messages, families received phone calls from instructors who talked learners,

[12] This must be balanced with an awareness of learning curves that come with the introduction of new technology, which influence the initiative's effectiveness.

parents and caregivers through the numeracy problems). Learning gains of 0.16 to 0.29 standard deviations were observed for the two interventions. Further, the researchers calculated USD 13.3 per standard deviation gain in learning for the SMS only group and USD 48.28 per standard deviation gain for the phone and SMS group. These estimates were deemed as cost-effective when compared to other interventions; the use of mobile devices that families already owned and were familiar with lowered intervention costs. Results are pending from a second wave of the pilot that provided targeted text messages based on a child's learning level (↑Angrist et al., 2020).

Another study on targeted messaging examined the impacts of sending differentiated and personalised texts to the parents of pre-primary students participating in a US-based programme (Ready4K). The Ready4K initiative provided parents with information on the "skill of the week" and home activities based on that skill that promoted parent–child interactions. During this study, the researchers additionally informed parents of how well their child knew a particular skill and provided activities tailored to the child's skill level via SMS messages. The study found that the differentiated and personalised texts had a significant effect on literacy outcomes for children; learners receiving such texts were 50% more likely to read at a higher level compared to learners who received general, non-differentiated texts (↑Doss, et al., 2017). Given the ubiquity of mobile devices in the US,[13] the intervention was characterised as low-cost, though the researchers did not specify the cost per student (↑Doss, et al., 2017). While the study suggests that the intervention was cost-effective, a cost-effectiveness analysis was not conducted in this study.

The two studies support that low-tech messaging initiatives can be used not only as a cost-effective tool to encourage parent–child interaction but also as a means for automated, personalised learning based on a child's skill level and needs. There may also be room for personalisation in messages that encourage school participation and the benefits of education. Over time, we expect to see a greater number of messaging initiatives that incorporate tech-enabled personalisation and adaptation that apply to both low-resource and high-resource contexts.

In general, the effects of messaging should be weighed against more costly initiatives that produce large improvements in learning outcomes but reach a smaller number of learners. This points to the need for education decision-makers to assess effectiveness alongside cost-effectiveness. Without doing so, only very cheap EdTech investments will be prioritised, leading to limited effects on learners. For instance, ↑Barrera et al. (2020) found that while a text messaging programme in Nicaragua enhanced caregivers' self-reported

[13] In the US, 97% of adults under 50 years of age have a cell phone and 98% use text messaging (↑ParentPowered, 2020).

parenting practices, no improvements in children's cognitive or socio-emotional outcomes were observed. With this in mind, decision-makers may consider leveraging low-cost messaging as a supplement to other education initiatives to maximise impact.

3.5. Case study 3: Tailoring learning processes to a child's learning level

Opportunities to personalise learning also present themselves in computer-assisted learning (CAL) programmes. An after-school programme for learners in urban India utilised the Mindspark software, which enabled self-led, personalised learning and was accessible online and offline via computers, tablets, and smartphones. A study conducted in 2018 reported significant learning gains for learners in urban India in maths and Hindi (0.37 and 0.23 standard deviations, respectively). The effects of the intervention did not differ based on gender, socio-economic status or baseline test scores, suggesting that positive learning outcomes were observed across all learners and marginalised learners were not excluded from the programme's benefits.

The programme cost per child, including infrastructure, hardware, staffing,[14] and software development costs was USD 180 per year (USD 15 per month); when scaled to 1,000 schools, the per-child marginal costs were estimated to be USD 2 per year. ↑Muralidharan et al. (2018) stated that: "even when implemented with high fixed costs and without economies of scale, and based on 58% attendance, providing access to the Mindspark centres delivered greater learning at lower financial and time cost than default public spending" (i.e., compared to the public school system). Personalised CAL via the Mindspark software accompanied by instructor support to promote the use of CAL was suggested to be the main driver of learning outcomes (↑Muralidharan et al., 2018).

A similar intervention conducted in China supports the finding that a key success factor is personalisation (with support from an instructor), not CAL or the technology itself. ↑Ma, et al. (2020) sought to isolate the effects of CAL from non-technology inputs. Learners in rural China were randomly assigned to one of three groups: (1) CAL, (2) workbook, or (3) control. The CAL programme included gamified activities, while the workbook was paper-based. Learners in both non-control groups completed maths exercises during weekly programme sessions without instructional support over the course of eight months.

[14] The authors did not specify whether the cost of the additional time that teachers spent on the after-school programme was included in this ingredient.

While the intervention implemented in rural China produced improvements in learners' maths grades, the use of technology in the intervention was not effective or cost-effective. The study found no effects on learning outcomes when the technology-based component was isolated (through comparing the CAL and workbook groups). This suggests that observed learning gains were largely due to other non-tech factors, such as the additional time that learners spent on various exercises. Further, the total cost of the CAL programme was higher than the workbook programme (USD 18 per child and USD 14 per child, respectively; ↑Ma, et al., 2020).

Overall, the two CAL programmes studied by ↑Muralidharan et al. (2018) and ↑Ma, et al. (2020) differed based on (1) whether the software adjusted to a child's learning level and (2) the amount and type of support that instructors provided. This supports the view that successful learning approaches, such as Teaching at the Right Level,[15] can be adapted to contexts with or without technology (↑Teaching at the Right Level, 2021).

[15] You can read more about the approach of Teaching at the Right Level here: https://www.teachingattherightlevel.org/

4. Complementary investments to maximise the cost-effectiveness of EdTech

When designing an EdTech initiative, an education decision-maker should take into account the ICT environment and broader components of an education system within a country (↑Kaye & Ehren, 2021). Depending on the local context, complementary investments that align with these system-level components can enhance the cost-effectiveness of an EdTech initiative, including investments across infrastructure; teacher professional development (TPD); and education policy, capacity and data. A brief overview of each investment and its links to EdTech is provided below.

4.1. Infrastructure

The availability of ICT infrastructure and devices is crucial in determining the effectiveness, cost-effectiveness, and equity implications of EdTech investments. In areas where there is no widespread access to electricity and connectivity (see Table 4), the costs of initiatives that rely on online learning will be high as infrastructure must be provided. As a result, the effectiveness of such initiatives must also be high for the initiatives to be cost-effective. In addition, the provision of EdTech in environments that are already electrified and connected tends to benefit the more advantaged members of society in the absence of specific offsetting initiatives.

Table 4. *Access to electricity and internet across the globe (↑World Bank, 2021).*

	Global	Sub-Saharan Africa	Low-income countries
Percentage of population with access to electricity	90%	48%	42%
Percentage of population with access to internet	49%	19%	16%

It is unrealistic to expect education budgets to cover connecting schools and learners to electrical grids and the internet, except in some circumstances to provide the relatively low-cost ‘last mile’ of each connection. Such infrastructure has to be considered within a national development plan, financed centrally and not be dependent on a Ministry of Education or equivalent (↑Unwin et al., 2020). Once connected, operational costs of electricity and internet access for schools can often be reasonably included in education budgets and should also be included within cost-effectiveness calculations.[16]

There is an ongoing and separate body of work surrounding the cost-effectiveness of infrastructural investments. Questions for decision-makers to investigate further will include:

- What types of connectivity services are most relevant for a certain country context (e.g., satellite, cable, optical fibre)? Should the available services vary based on the location within a country?
- Should procurement take place centrally or at a school level?
- What is the role of public-private partnerships in financing ICT infrastructure?

The Covid-19 pandemic and resulting school closures not only revealed the extent of limited access to electricity and connectivity, but also to devices. Ideally, investments in EdTech will follow a survey of device availability, including radio, television, computers, smartphones, and basic mobile phones (↑Haßler et al., 2020). This activity is key given the wide range of device ownership rates across countries. In East and Central Africa, for example, the proportion of households with a radio varies between 28% in Ethiopia to 71% in Kenya (↑Dreesen et al., 2020).

The cost-effective use of devices is linked to and dependent on the robustness of the local ICT infrastructure. Without sufficient access to electricity, many EdTech initiatives which leverage devices that require charging at home or at school will quickly become unsustainable, impacting the long term cost-effectiveness of an initiative (↑Coomar & Ryzhov, no date). Devices dependent on online access will be hindered in areas with low to no connectivity. Conversely, the presence of a strong enabling environment can enhance the reach of EdTech initiatives to marginalised learners, for example by reducing the rural-urban gap (as shown in Figure 5).

[16] Where such operational costs cannot initially be covered by education budgets, there is a case for aid to cover them. However, eventually, they should be paid for from domestic budgets. There are ambitious programmes to connect every school to the internet, like the UNICEF-ITU GIGA programme, which was launched in 2019 and aims to accomplish this goal by 2030. Achieving this would require significant financial investment; UNICEF has estimated that connecting all schools around the world would cost USD 428 billion (↑UNICEF, 2020).

Figure 5. *Computer-assisted learning (CAL) enabled by infrastructural investments in China (↑Bianchi et al., 2020).*

In 2000, high school enrolment rates across China were 9.4 times higher in urban than in rural areas. This disparity was largely due to larger classes, fewer resources, and poorly trained teachers in rural schools, compared to urban schools. In response to this issue, a large-scale reform, conducted in 2004 and embedded within evolving national education policy, connected high-quality urban teachers with over 100 million rural primary and secondary school learners via satellite internet.

The programme had three aspects:

1. The provision of 440,000 DVD-TV sets to play CDs recorded by teachers in urban areas;
2. The installation of 250,000 satellite receiving sets to permit internet delivery of lectures and learning materials;
3. The construction of 41,000 computer classrooms.

The researchers noted that access to well-trained teachers through remote learning was the key driver of the reform's success and only made possible through complementary investments in hardware and infrastructure. The CAL programme was estimated to reduce the rural-urban gap in school years by 21%, with a cost per child of CNY 111. The cost-benefit analysis demonstrated that the cost per child of the CAL programme was much lower than the estimated individual increase in earnings discounted over the life cycle. However, while this initiative provided detailed information on costs and impact, the study did not include comparisons of programme costs with other initiatives. As a result, the cost-effectiveness of the CAL programme has yet to be determined.

4.2 Teacher professional development

Most EdTech investments continue to rely on teachers, with many initiatives designed to expand their reach and impact on learning. Yet sufficient attention is not always directed towards the need to conduct digital literacy training for teachers, supporting their familiarity with using EdTech themselves and helping their learners to use it. In Indonesia, for instance, adopting EdTech at scale and achieving an impact comparable to other countries is unlikely until there is an increase in digital literacy among teachers

(↑Bhardwaj et al., 2020; ↑Pouezevara et al., 2019). More broadly, there is evidence that effective use of EdTech in the classroom is related to the level of training and support provided to teachers (↑Warschauer et al., 2004). Ongoing and regular TPD positively correlates with successful EdTech take-up (↑Allier-Gagneur et al., 2020; ↑Piper et al., 2015; ↑Tauson & Stannard, 2018; ↑Warschauer et al., 2004).[17]

It is important to consider whether TPD should be included in the design of EdTech projects. If yes, decision-makers should ensure that costs related to this ingredient are captured. This is increasingly the case across recent initiatives. For example, the ↑Ma et al. (2020) study referenced in Section 3 used an ingredients approach to measure costs, including the cost of training facilitators that was then factored into the cost-effectiveness analysis. The ↑Angrist et al. (2020) study similarly included fixed costs of instructor training when calculating cost-effectiveness.

One central question among education decision-makers is whether EdTech can improve the cost-effectiveness of TPD programmes by keeping costs low, while still maintaining learning gains. Figure 6 highlights an example of a TPD initiative that utilises technology to drive down programme costs. Findings supported that tech-enabled TPD programmes can be cost-effective, especially for the weakest classrooms.

Figure 6. *Tech-enabled teacher professional development in Brazil (↑Bruns et al., 2017).*

An intervention in the state of Ceará provided secondary school teachers with expert coaching via Skype and in-person feedback from classroom observations. The programme cost USD 2.40 per child; the use of Skype ensured lower costs, as the highest cost driver in the study was the in-person school visits. Further, the cost of using Skype was minimal as all schools had working internet and computers.

One standard deviation increase in learner test scores cost USD 29 per child for maths and USD 47 per child for Portuguese. However, for classrooms in the bottom quartile of classroom management at baseline, the cost of a one standard deviation improvement dropped to USD 16 per child for maths, and USD 18 per child for Portuguese. This finding suggests that targeting the programme to classrooms and learners that require the most support improves cost-effectiveness. Overall, the programme was found to be cost-effective relative to other comparable TPD programmes.

[17] For more information on TPD and EdTech, you can read the Hub brief here: https://edtechhub.org/characteristics-of-effective-teacher-education-in-low-and-middle-income-countries-what-are-they-and-what-role-can-edtech-play/

4.3. Education policy, capacity and data

EdTech investments are most effective and cost-effective when sufficiently integrated into an appropriate policy framework and when education institutions have demand and are prepared to use EdTech. The Omidyar Network identifies the following components of an education policy and strategy that will support the scaling of EdTech:

1. A clear vision and strategy for EdTech from the highest level of the education system;
2. Performance standards for EdTech software and content development;
3. Expectations for digital literacy for teachers and learners that are incorporated into policies and curricula;
4. Equitable sources of funding for EdTech (↑Pouezevara et al., 2019).

At a minimum, decision-makers should check that the policy environment and the broad sectoral capacity either are or will be, sufficiently developed to accommodate EdTech. For example, in China, national policies are focused on the allocation of funding towards improving access to ICT infrastructure, enabling add-on EdTech initiatives such as the 2004 CAL reform discussed in Figure 5 (↑Pouezevara et al., 2019). ↑Bianchi et al. (2020) noted that high compliance to government policies in China could have further enhanced the educational benefits of the CAL programme. The presence of a clear vision and strategy, as well as expectations for schools and teachers to use EdTech, enabled rural schools to successfully adopt the tech-based components (DVD-TV player sets, satellites, computer classrooms) with little resistance.

EdTech initiatives can also be enhanced by improved, often tech-supported, processes for data collection. In Pakistan, real-time school monitoring systems feed data to decision-makers who can then direct funds and tailored initiatives to schools in need (↑Global Partnership for Education, 2019). Enhancing data processes can improve decision-making about where to locate new schools, where to assign teachers and how to support underperforming schools, among other activities. Data is also increasingly important as donors and governments have begun to move towards results-based financing, which is only feasible with accurate, timely, and verifiable data. As with its contributions to teaching and learning, however, tech-supported data can only be helpful if there is a policy environment that welcomes and uses it.

4.4. Country readiness checklist

It is important to identify and assess the presence of each of the above complementary investments in a certain context. Such activities can help determine whether the enabling environment will support the cost-effectiveness of an EdTech initiative. To assess country readiness for EdTech, we recommend that a decision-maker consider the following non-exhaustive list of questions (↑Adam et al., 2021).[18]

- Is the digital infrastructure mature enough?
- What available devices can be leveraged for learning?
- Is there sufficient human capacity, in addition to opportunities for continuous professional development?
- Is there a supportive ecosystem across the developer community, donor community, and education community?
- Is there sufficient funding to develop, adapt, and maintain the initiative?
- Is there support from political economy stakeholders, policy and data systems?

[18] For more information on assessing country readiness and related country case studies, you can refer to the Hub report here: https://docs.edtechhub.org/lib/PIXT9J66

5. Future directions

This brief serves as a starting point for future research and guidance that may include, but not be limited to, the following areas:

- **Embedding cost-effectiveness within EdTech research.** There is a need to encourage and incentivise the collection of accurate, relevant, and consistent data on cost-effectiveness in EdTech initiatives. A mixed-methods approach can be utilised to combine narrative explanations with quantitative metrics, highlighting nuances within the findings and local context. Additional considerations regarding when to best conduct cost-effectiveness analysis require further investigation.
- **Continuing work on the intersections of equity and cost-effectiveness.** Rather than a single value, ranges of cost-effectiveness can be examined and compared across different learner groups. This will help ensure that cost-effectiveness discussions do not exclude marginalised groups. Such work can build on existing efforts by ↑Johri & Norheim (2012) and ↑Sabates et al. (2018).
- **Studying cost-effective EdTech in a post-Covid world.** As more studies on learning during the Covid-19 pandemic are released, our current understanding of what works, for whom, when, where, and how for EdTech may shift. While initiatives that are in-person and low- or no-tech can be cost-effective, they may not be relevant in post-Covid scenarios that require remote or blended learning.

For EdTech to contribute towards addressing the global learning crisis, generating evidence and good practices on cost-effectiveness and EdTech is essential. This knowledge, supported by frameworks and tools to conduct cost-effectiveness analysis, will enable us to make informed decisions about initiatives that can be implemented and scaled for all learners.

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Appendix: Resources on measuring cost-effectiveness

Acknowledging the existing body of work on evaluating cost-effectiveness, this appendix provides a curated list of available resources that a decision-maker can refer to in order to measure cost-effectiveness.

1. Measuring costs

1.1. Capturing cost data (Strategic Impact Evaluation Fund and International Rescue Committee note)

This note highlights that cost data should be disaggregated, initiative-specific, and captured in real time. Accurate cost data is disaggregated by quantities, intensity of use and prices applicable at the time of the initiative. Examples of specific inputs that should be included in a cost model include teacher salaries calculated by months employed and learning materials calculated by the number of packages.

Ensuring that data is initiative-specific and from multiple sources additionally leads to greater accuracy. It can help capture the level of effort for staff members (i.e., pinpointing the amount of time dedicated to the initiative). Lastly, collecting data in real time helps to avoid downward biases in cost (↑World Bank & International Rescue Committee, 2019).

1.2. Costing remote learning encouragement (Strategic Impact Evaluation Fund template)

This excel template and accompanying guidelines provide a practical tool to calculate the total cost, average cost, and cost-effectiveness ratio for remote learning initiatives. The template was specifically designed for nudge or information interventions funded by the World Bank's Strategic Impact Evaluation Fund (SIEF) for programmes implemented during Covid-19. While the resources can be used for other initiatives, users should note that the tool does not adjust for inflation or calculate the present value, as Covid-19 programmes were initially expected to last less than one year (↑Blagrave, 2020).

1.3. Cost measurement for donor-funded education programming (Building Evidence in Education note)

This guidance note builds on the experiences of the UK Foreign, Commonwealth and Development Office (FCDO), USAID, and the World Bank with collecting and using cost data. The partners aim to establish a shared framework among donors for recording, analysing and utilising cost information to maximise the impact of education programmes within a context of limited resources. The proposed framework comprises three elements:

1. the objectives of cost measurement;
2. the approach to capturing cost data;
3. the analysis of cost data.

In particular, the authors emphasise the importance of articulating the 'why' of cost measurement (that is, the questions that cost measurement seeks to answer) before setting out to capture and analyse the data. The guidance note recommends that activity-based costing (i.e., documenting costs per individual activity) is used to capture costs. The brief also includes a discussion of how to use cost analysis to elucidate the *features* of programmes, and the contexts in which they are implemented, that contribute to costs and / or provide value for money (↑Walls et al., 2020).

1.4. Cost analysis guidance for USAID-funded education activities (USAID note)

USAID's cost analysis guidance for education initiatives adds value to this set of literature by discussing more detailed aspects of identifying and calculating costs, such as calculating depreciation on tangible and intangible assets. In particular, the report highlights the importance of including the opportunity cost to programme participants as part of the cost-capture exercise. Individuals who participate in training as part of an education initiative may be forgoing other activities that could produce value for them or their communities. For example, parents and caregivers may need to take time off work in order to attend school or community meetings. While this resource is USAID-specific, it can be applied across cost-capture exercises more generally (↑Walls et al., 2020).

2. Measuring impact

2.1. Learning-Adjusted Years of Schooling (LAYS) (World Bank report)

This background paper introduces Learning-Adjusted Years of Schooling (LAYS), a new measure of education that was developed by the World Bank in 2018. Reflecting the growing acknowledgement that the number of years spent in school does not necessarily lead to learning, LAYS captures both the length of time students spend in school, as well as the quality of education they receive while there. In this way, LAYS demonstrates the learning productivity of an education system, and further emphasises that a year of schooling in one country may yield far less learning than a year of schooling in another country.

Given that LAYS accounts for both the quantity and the quality of schooling, it is highly useful when calculating and comparing the cost-effectiveness of education programmes or systems. At the macro level, LAYS can be compared with per-child spending to provide a snapshot of the overall cost-effectiveness of education systems around the world. At the micro-level, LAYS can be used to compare the impact of different education initiatives on learning outcomes. While most education initiatives calculate impact either in terms of additional years of schooling or improved quality, LAYS can be used to adjust each measure to take into account impacts on both quantity and quality. For example, calculating the marginal increase in LAYS per learner gained from an investment of USD 100 in different programmes can provide decision-makers with crucial information on value for money (↑Filmer et al., 2018).

2.2. Does Education Need a Quality-Adjusted Life Year measure (QALY) and is LAYS it? (Center for Global Development blog)

While LAYS is acknowledged as a useful measure of impact in education, there are some limitations that policymakers should consider. First, the fact that LAYS is based on test scores overlooks other forms and benefits of learning. LAYS does not take into account socio-emotional learning, which is not measured by international standardised tests. The LAYS metric also does not consider the secondary benefits of being in school, such as delayed marriage, which may be particularly notable in LMICs with otherwise low test scores. In addition, as the Center for Global Development notes, there is limited evidence that improved school quality leads to higher rates of return on investment in the labour market in LMICs (↑Crawfurd et al., 2019).

Second, LAYS requires comparable data on education quality across countries, which can be difficult to come by. The World Bank's dataset on harmonised learning outcomes[19] can provide such data, but relies on multiple and highly varied international assessments as well as a complex data conversion process (↑Patrinos & Angrist, 2018).

[19] The World Bank's global dataset on education quality can be accessed here: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/390321538076747773/global-dataset-on-education-quality-a-review-and-update-2000-2017

The third limitation relates specifically to the use of LAYS on the micro-level to compare the outcomes of programmes (and ultimately their cost-effectiveness). For this purpose, LAYS requires data from a comprehensive learner assessment that covers total expected learning in a school year; this type of assessment is uncommon and would require a change in evaluation approaches (↑Crawfurd et al., 2019).

2.3. Cost-effective approaches to improve global learning (Global Education Evidence Advisory Panel report)

This report uses the LAYS measure combined with data on cost-effectiveness to compare education initiatives in LMICs. Initiatives are sorted into four tiers, from 'great buys' to 'bad buys', based on the LAYS gained per student per USD 100 spent per student. Considering the element of cost-effectiveness on top of LAYS provides additional information. For example, the sole 'great buy' identified (providing information on educational benefits, costs, and quality) has moderate effects in terms of LAYS, but is very cheap to implement, making it the most cost-effective initiative out of those considered. At the same time, these information initiatives can vary greatly in cost-effectiveness. Of the two rigorous costed studies identified in ↑Angrist et al. (2020), one shows a gain of 140.99 LAYS per student per USD 100 spent, and another shows a gain of 0.04 LAYS per student per USD 100 spent. Conversely, while an initiative such as school construction may be impactful in terms of LAYS, the high price tag limits its cost-effectiveness. In general, considering cost-effectiveness and LAYS in tandem can help decision-makers maximise their financial resources and avoid programming that does not provide value for the money spent (↑Global Education Evidence Advisory Panel, 2020).

2.4. Education Sector Analysis Methodological Guidelines (Volume 1)

This resource, authored by UNESCO, the World Bank, UNICEF, and the Global Partnership for Education, covers a broad range of topics related to analysis within the education sector, with a focus on primary and secondary education. Chapter 4 offers guidance on how to measure learning outcomes, including a discussion of different sources of learning data (e.g., national exams), as well as how to analyse the cost-effectiveness of different factors that affect learning outcomes. Chapter 5 covers how education affects broader social, economic, and human development goals at a national level, such as labour market outcomes. This chapter may be particularly useful for decision-makers who are seeking to measure cost-effectiveness in terms of impact on higher-level objectives (↑Global Partnership for Education, 2014).