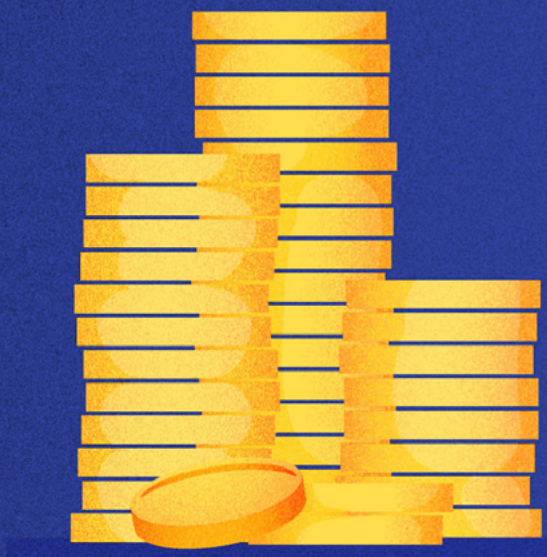
DIGITAL LEARNING FOR DEVELOPMENT



Cost-effectiveness of digital learning for development: Towards a systematic, systemic, and sustainable framework

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Published by
Foundation for Information Technology Education and Development, Inc. (FIT-ED)
3/F Orcel II Building
1611 Quezon Avenue
Quezon City 1104 Philippines

Digital Learning for Development
www.dl4d.org

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This work was created with financial support from the UK Government's Department for International Development and the International Development Research Centre, Canada. The views expressed in this work are those of the authors and do not necessarily represent those of the UK Government's Department for International Development; the International Development Research Centre, Canada or its Board of Governors; the Foundation for Information Technology Education and Development; or the editors.

Recommended citation
Vrasidas, C. (2020). *Cost-effectiveness of digital learning for development: Towards a systematic, systemic, and sustainable framework*. Quezon City, Philippines: Foundation for Information Technology Education and Development.

Book design
Dustin Ibañez

Icon design
monkik from www.flaticon.com

Cover illustration and layout
Paolo Tan

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ACRONYMS

3SIGMA	Systemic, Systematic, Sustainable
CEA	Cost Effectiveness Analysis
CWtL	Can't Wait to Learn
DL4D	Digital Learning for Development
ICT	information and communication technology
OECD	Organizations for Economic Cooperation and Development
OER	Open Educational Resources
SDGs	Sustainable Development Goals
UNESCO	United Nations Educational, Scientific and Cultural Organization

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ABSTRACT

Information and communications technology is regarded as an accelerator of development and growth with strong potential to improve the quality of education worldwide. Although global spending on education has increased dramatically, evaluations rarely examined the costs of programs in relation to their impact. Cost-effectiveness analysis is a process that can support decision-makers develop evidence-based policies. The focus of this paper is to examine the issues around the cost-effectiveness of Digital Learning for Development (DL4D) regarding quality, equity, and efficiency, providing recommendations for scalability and sustainability. One theme that emerged from this research is the need for more systemic and participatory approaches to program design, to ensure the needs of stakeholders and end users are addressed. A systemic, systematic, and sustainable framework is proposed to facilitate the study, adoption, sustainability, and scalability of DL4D.

1

INTRODUCTION

During the last four decades, there has been an increased interest in examining the role of information and communications technology (ICT) in education in developing countries (Results for Development Institute, 2016; Trucano, 2005). ICT is regarded as an accelerator of development and growth, and several global initiatives have targeted the use of ICT for digital learning, education, and development (Results for Development Institute, 2016; Daniel, 2010; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015b). In this paper, we will use the term Digital Learning for Development (DL4D) to refer to both the integration of ICT in education, and support programs for the successful use of digital learning that include professional development of teachers, curriculum development, assessment, and related activities.

The United Nations in 2015 established the Agenda 2030, consisting of 17 sustainable development goals (SDGs). These goals aim to stimulate action regarding the five P's of critical importance: people, planet, prosperity, peace, and partnership (UNESCO, 2015a). The sustainable development goal in education (the SDG4) is the driving force that can support the achievement of the SDGs. The costs of education have grown substantially over the last few decades. More funds are needed to provide the infrastructure and teachers needed to achieve the education for all agenda and reach out to millions more children (UNESCO, 2015a). Policy papers by UNESCO show that an additional US$39 billion is needed annually over 2015-2030 to reach quality universal pre-primary, primary, and secondary education in low-income and lower middle-income countries (Wils, 2014).

In times of financial crisis, the budgets and spending of governments and international development agencies are under scrutiny. There are two key questions related to costs:

- How can resources be invested effectively and efficiently?
- How can the cost-effectiveness of programs be established?

Cost-Effectiveness Analysis (CEA) is a process that can support policymakers reach informed decisions on program development and resource allocation (Jimenez & Patrinos, 2008; Levin & Belfield, 2015; Levin & McEwan, 2001). This paper will synthesize knowledge on CEA, DL4D, interventions that improve learning, and factors that influence the success of DL4D. It will then present recommendations for policy

and practice. Emphasis will be on CEA in the context of DL4D with respect to quality, efficiency, and equity.

Attempts to define quality in education are value-based. Barrett, Chawla-Duggan, Lowe, Nikel, and Ukpo (2006) identified two approaches to defining quality: the humanist/progressive approach focusing on human development, social change, and the child as a whole; and the economist approach focusing on efficiency and effectiveness of achieving learning outcomes at optimal costs. In the literature and in documents by international organizations, quality education and education effectiveness are often equated, among others, with schooling (as measured with school attendance), improved learning (as measured with test scores and international comparisons such as PISA), teacher-to-student ratios, access to curriculum resources and textbooks, and teacher quality (Organisation for Economic Co-operation and Development [OECD], 2006; UNESCO, 2014, 2015c). In the Agenda 2030, quality education focuses on "improving learning outcomes, which requires strengthening inputs, processes and evaluation of outcomes and mechanisms to measure progress" (UNESCO, 2015a, p. 7) as well as on providing lifelong learning opportunities for all. Regarding DL4D, quality covers aspects such as competencies and readiness of teachers to teach with ICT, quality of digital resources, availability and reliability of infrastructure, and attributes of pedagogical design in integrating ICT in teaching and learning (Daniel, 2010; Kleine, Hollow, & Poveda, 2014; OECD, 2015; Trucano, 2013). Equity refers to the degree to which digital learning is fair and inclusive by providing equal opportunities to all learners, so they can benefit equally and achieve their full potential (Daniel, 2010). Efficiency refers to the degree to which resources are used in ways that achieve the best desirable outcome possible, given the context of implementation of digital learning (Kleine et al., 2014).

In preparing this paper, we critically reviewed literature published in scholarly journals, books, online databases, and websites of international organizations active in the areas of development, education and ICT. Papers and studies selected to be included in this review met the following criteria:

- Relevance to the key issues discussed and addressed in this paper (e.g., DL4D, CEA, education in developing countries, scalability, and sustainability).
- Published by a credible source (e.g., scholarly journal, book, reports on credible sites of international organizations and other agencies).
- Conducted after the year 2000. Past research is only cited to show a historical perspective.
- Examined multiple perspectives (contradicting at times) of the key issues providing a holistic view of CEA in the context of DL4D.

Our emphasis was to identify examples of CEA conducted within the context of developing countries. A big challenge is the dearth of rigorous research in the area of cost-effectiveness of learning interventions in developing countries, with even less on cost-effectiveness on DL4D. Many research with regard to cost-effectiveness and DL4D are inconsistent, and evaluation results depend heavily on program objectives, context, method of implementation, and data collected and analyzed (Evans & Popova, 2015). We also drew on our own work at the non-profit organization, the Center for the Advancement on Research and Development in Educational Technology[1], where we designed and implemented more than 150 projects around the world, in both developed and developing countries (Vrasidas & Glass, 2002, 2004, 2005; Vrasidas, Glass,

[1] *http://www.cardet.org*

& Zembylas, 2009). There is a strong need for more careful evaluation of the impacts of programs and the cost consequences for the short-, medium-, and long-term. Such research can inform policymakers and practitioners on the processes to follow for scalability and sustainability of DL4D across contexts.

In the following sections, we examine the aspects of cost analysis in education in relation to evidence-based decision-making. We then discuss cost analysis with a focus on educational evaluation and place emphasis on CEA, present the ingredients method for conducting CEA, and examine the assumptions and limitations of CEA. Once the background for CEA is established, we focus on cost-effectiveness in relation to DL4D, looking at the costs of DL4D, ICT and quality in education, and CEA of learning interventions. We then discuss the challenges for conducting CEA and propose ways to address them. In the final section, we synthesize the literature and present the 3-Sigma (systemic, systematic, and sustainable) framework for scalability and sustainability of DL4D.

2

COST ANALYSIS APPROACHES AND EVIDENCE-BASED DECISION-MAKING

A key issue in program evaluation often overlooked is cost analysis. Although global spending on education has increased dramatically, CEA studies did not follow a similar trend. As a process, CEA can support decision-makers develop policies based on evidence, a big push among donors and international agencies (International Institute of Educational Planning [IIEP], 2017; USAID, 2016). CEA in education evaluation was first discussed by Levin (1975) and later in a revised book on the subject by Levin and McEwan (2001). Since then, several studies have been reported and CEA is discussed within the context of evidence-based policy-making (Belfield et al., 2013; Dhaliwal, Duflo, Glennerster, & Tulloch, 2012; Hollands et al., 2015; Jimenez & Patrinos, 2008; Levin & Belfield, 2015; McEwan, 2012, 2015; Schiefelbein, Wolff, & Schiefelbein, 1998).

Before examining the process for conducting CEA, it is important to reflect on some of the key issues around financing DL4D. Trucano (2005) stated:

> Most cost studies neglect to ask perhaps the most fundamental question: Can you reach the same educational goals and objectives in a different manner at less cost without using ICT? (p. 22)

Below are some indicative questions to consider when conducting cost analysis of DL4D (Belli, Anderson, Barnum, Dixon, & Tan, 1998; Jimenez & Patrinos, 2008; Trucano, 2005). The list is not exhaustive. More issues and questions are raised and discussed in subsequent sections.

- What are the aims and objective of the project?
- What will happen if the project is undertaken? What if it is not? This is important for assessing the incremental costs and benefit.
- Are there any alternatives to the project? Can the same objectives be reached more effectively and with less cost with other means?
- Are the various components of the project economically justified?
- Who gains and who loses if the project is implemented, and what is the cost?
- What is the fiscal impact of the project? Is the project worthwhile?
- Is the program addressing digital equity?

- Is the project financially sustainable and scalable?
- What are the potential risks involved?
- Are there any other externalities? What is the environmental impact of the project?

The most common approaches to cost analysis in educational evaluation are cost-effectiveness analysis, cost-benefit analysis, cost-utility, and cost-feasibility (Jimenez & Patrinos, 2008; Levin & McEwan, 2001; Perkins, Radelet, & Lindauer, 2006).

2.1 Cost-effectiveness analysis (CEA)

CEA is a method used to identify the relative costs of programs compared to their outcomes. According to Levin and McEwan (2001), a strength of CEA is enabling cost-effectiveness comparisons by comparing cost and effectiveness data from two similar programs. A widely-used approach in estimating costs and conducting CEA in education is the ingredients method, where all ingredients needed for a program are identified, their prices ascertained, and their costs calculated (Levin & Belfield, 2015; Levin & McEwan, 2001). For this paper, we focus on CEA and the ingredients method for cost analysis in the context of DL4D. All the details about CEA are presented in subsequent sections of this paper.

2.2 Cost-benefit analysis (CBA)

CBA compares the costs of programs with the benefits they produce. In CBA, a monetary value is assigned to all benefits (Jimenez & Patrinos, 2008; Levin & McEwan, 2001; Perkins, Radelet, & Lindauer, 2006). CBA compares the money spent on a program with the benefits earned from the program, which are estimated in monetary terms. Evaluating all alternatives in terms of monetary values of costs and benefits allows evaluators to examine which interventions have benefits that exceed their costs, and identify which programs demonstrate the highest cost-benefit ratio. However, assigning monetary values to all benefits is difficult and requires more data and analysis than CEA.

2.3 Cost-utility analysis (CUA)

CUA is usually conducted when not enough data are available to conduct a proper CEA, and serves a difference purpose. CUA examines the costs and utility/value of a program, as measured by stakeholder satisfaction. While CEA relies on a single measure of effectiveness, CUA examines the overall satisfaction of stakeholders, often using a combination of measures of effectiveness. CUA has been widely-used by evaluators in the field of health (Levin & McEwan, 2001).

2.4 Cost-feasibility analysis

Cost-feasibility analysis is conducted to estimate the costs of a program before its implementation. The approach provides stakeholders and policymakers with data on whether a program is worth the resources and efforts to fully develop and implement.

3

COST ANALYSIS IN EDUCATIONAL EVALUATION

3.1 The ingredients method for CEA

For proper CEA, both costs and effectiveness data are required. In this section, we briefly discuss the ingredients method for cost estimation and conducting CEA, as proposed by Levin and McEwan (2001). The emphasis is on cost estimation and not on measurement of the effectiveness of programs. Assuming the effects of programs are measured and established, the ingredients method is used to estimate costs by identifying all ingredients/resources used for implementing a program.

The ingredients method is the primary approach for establishing the costs of programs, and has been used widely in education (Belfield et al., 2013; Dhaliwal et al., 2012; Hollands et al., 2015; Jimenez & Patrinos, 2008; Levin & Belfield, 2015; Levin & McEwan, 2001; McEwan, 2012, 2015). It is the only way to get as accurate estimates as possible of education interventions, since it aims to account for all ingredients needed to implement a program. Alternative approaches, such as relying on the program budget, fail to provide accurate estimates of costs. Without all costs estimated, it is difficult to guarantee comparability between programs. Implementing a program requires resources that are often not covered in the budget. Given the fact that costs are incremental, it is important to identify and cost all ingredients. In times of financial constraints, every dollar matters. This is particularly important in the Global South, where resources are limited, and every dollar matters even more.

3.2 Assumptions of conducting CEA

The key assumptions for using the ingredients method, as discussed by Levin and McEwan (2001), and Levin and Belfield (2016), are described below.

- CEA is based on the idea of comparison of costs and outcomes among two or more programs.
- For valid cost-effectiveness estimates, the alternative programs compared should have similar objectives, and the measures of these objectives and outcomes also need to be similar.
- The programs need to have clearly defined goals and expected outcomes. If multiple outcomes are expected, all outcomes need to be reduced to a single measure for each program with some weighing scheme.
- It is important that researchers clearly describe the programs under comparison and clearly

document all processes, activities, and aims of the programs.

- Researchers need to consider the results of the different programs/alternatives (different solutions to solve the problem), and the ways in which effectiveness of the programs in achieving the specific objectives will be measured.

- For better results, cost data need to be collected simultaneously with impact and effectiveness data.

- An important aspect of costs in CEA studies is that these costs are mostly incremental. That is, the costs of a program are at times additional funds spent over and above to the already existing programs (e.g., school lessons).

From the above assumptions, it is evident how difficult it is to conduct CEA in DL4D when there is a diverse set of programs, countries, contexts, interventions, and technologies used.

3.3 The ingredients method

The ingredients method is used to compare the costs and effects of two or more similar programs. Assuming the effect size of each program is established and reduced to a single indicator, the basic steps for using the ingredients method to define the costs of a program is presented in Figure 1, and described below.

Identify ingredients. Clearly identify all ingredients (resources) used to implement the program. In cases where the ingredients cannot be defined clearly, an average implementation of the program can be costed. The most common key ingredients of education programs are staff, facilities, equipment, supplies, and travel. To reach as accurate conclusions as possible about costs, a detailed initial list of ingredients needed to implement each program should be prepared by reviewing the project plans and relevant literature, and by consulting with key stakeholders. Based on the initial review, a template cost sheet can be prepared to be used to collect and document costs. Follow-up interviews with key stakeholders might be needed to verify all ingredients used.

Define the price of each ingredient. Once ingredients are identified, the next step is to ascertain their prices. There are several approaches for costing the ingredients. The key is to clearly explain and justify what method is used. This will allow policymakers to reach their own conclusions about the findings of the analysis. One approach is to use market prices for various ingredients, which is simple and usually has readily-available data. Using exact costs is preferred when data exist and are easy to access. The costs should be accounted as incremental costs, meaning costs necessary beyond the normal operations of a program or school. Adjusting for inflation and discounting costs should be considered for projects that last more than a year.

Figure 1. *Costing a program using the ingredients method adapted from Levin and McEwan (2001).*

To properly ascertain staff costs, one needs to consider the education level, experience, skills, and salary for each staff involved in delivering the program. We know from research that around three quarters of the costs of education programs in the developed world are staff costs. The Results for Development Institute (2016) reports case studies from several countries including Sudan and Peru, where ICT increased access to education and scaled to the next level of implementation with positive results. Several studies have documented the potential of using ICT to increase access to education (Daniels, 2010; Vrasidas et al., 2009; Wagner et al., 2014). Further, according to UNESCO (2015a), crisis and conflict are among the biggest barriers to achieving quality education for all. In a recent report, Dahya (2016) argued that ICT has the potential to support education for the marginalized with tools like radio, mobile phones, e-readers and tablets, and laptops.

3.4 Challenges in using the ingredients method

Challenges in using the ingredients method in estimating costs of programs have been documented (Belfield & Levin, 2013; Dhaliwal et al., 2012; Evans & Popova, 2015; Levin & McEwan, 2001; McEwan, 2015). Among these are:

- Identifying all resources used in a program not always easy nor feasible.
- Defining the prices for ingredients when not enough data is available.
- Convincing project teams to collect cost data, and collect them simultaneously with the effectiveness data.
- Understanding that most interventions have incremental costs.
- Accepting that the costs of a program are not only those listed on the budget of the program.
- Understanding that costs are estimates.
- Ensuring accurate estimates of costs, given the fact that in several cases some of the costs are based on self-reporting.

3.5 The costs of DL4D

Discussions on how technology and online education can reduce costs are not always grounded on evidence (Bakia, Shear, Toyama, & Lasseter, 2012; Bartley & Golek, 2004; Jung, 2005; Levin, Glass, & Meister, 1987; Meyer, 2014). Claims that technology reduces the costs of education, as if the large percentage of costs is associated with hardware, are misleading (Levin, 1986; Rumble, 1997; Trucano, 2005). ICT have the potential to reduce costs when used, for example, in distance education to teach large numbers of students, but large up-front investments are required (Daniel, 2000; Rumble, 1997). Technology is only a small part of the complex ecosystem supporting education, and its successful integration requires effective and efficient use by trained staff, solid infrastructure, curriculum decisions that match the technology affordances, aligned assessment practices, technical support, maintenance, and other services. All these add to the overall cost of education.

We know very little about the cost-effectiveness of DL4D, for example, the cost-effectiveness of Open Education Resources (OER), which have not been examined in detail. Claims that OER can reduce costs are based on the idea that OER can be used, reused, adapted, and integrated in programs (Miao, Mishra, & McGreal, 2016). However, issues such as up-front development resources needed, copyright, training, language, and localization, are obstacles which can be costly to overcome. Miao

et al. (2016) argued that OER are not cost-free, and we argue that the cost-effectiveness of various approaches to using OER remains to be documented.

Research has shown that the costs of technology increase when moving from simple to more advanced tools; television costs more than radio, and computers and the internet cost more than television (UNESCO, 2001). Trucano (2005) argued that interactive radio has been documented as the most cost-effective technology used in developing countries. He also argued that scaling up ICT in least-developed countries is unlikely to be cost-effective or even possible. One of the greatest cost-effectiveness potential of ICT in developing countries might be its contribution to improve organizational and systemic efficiencies.

3.6 ICT and quality of education

There is contradictory evidence in the literature on whether ICT can improve conventional teaching and learning. Although ICT has the potential to support reform and improve teaching and learning, the realities of schools and education systems around the world do not demonstrate the expected impact from its use (Cuban, 2001; Ganimian & Murnane, 2016; Glewwe & Muralidharan, 2015; OECD, 2015; Trucano, 2013). Even though access to ICT has increased substantially, the use of digital tools has not followed a similar trend. Research in several contexts, cultures, and countries reveal that although there is dramatic growth in the availability of ICT in schools in most of the developed world, teachers do not use technology as expected (Aldunate & Nussbaum, 2013; Mehlenbacher, 2010; OECD, 2015).

The reasons ICT failed to deliver on its expectations touch on the realities and culture of the everyday classroom; diverse cultural and country contexts and needs; and teachers' knowledge, skills, beliefs, and expertise (Cuban, 2001; Ganimian & Murnane, 2016; Mehlenbacher, 2010; Vrasidas, 2015). Some of these challenges also apply in several developing countries and contexts. Additional challenges related to developing countries, and which stem from the limited resources available and/or issues such as history, crisis, and conflict, include teacher qualifications and skills; access to schooling; availability of quality digital resources, content, and tools; availability and reliability of internet and electricity; broadband access; support for teachers and schools; and lack of proper policies (Dahya, 2016; Results for Development Institute, 2016; Trucano, 2005, 2015).

A key challenge of using DL4D relates to the fact that digital tools can help achieve specific objectives, provided the objectives of programs match the affordances of these tools (Vrasidas & Glass, 2005). Failure to match the affordances of ICT to the context, needs, and objectives of projects often leads to inefficient use of resources (Trucano, 2013). Further, for ICT to have a positive impact on learning and the quality of education, several factors need to be considered. Among these are contextual factors, cultural factors, policies, socioeconomic factors, support, curricula, teaching and assessment practices, monitoring and evaluation, teacher capacity and professional development, and sustainable and long-term planning (Cuban, 2001; Results for Development Institute, 2016; UNICEF, 2017; Vrasidas et al., 2009).

4

COST-EFFECTIVENESS ANALYSIS OF DL4D

Compernolle and Visser-Valfrey (2011) conducted a literature review to examine what the research says about the effectiveness of investments in education. They addressed two key questions: 1) Does education contribute to development and if so, how?; and 2) What programs in education work best, and why?

In examining the impact of education for development, the authors considered the human rights argument for education (e.g., education and equity for all), and the potential contribution of education to human and economic development. Their analysis showed that education can support human development; lead to higher individual earnings; increase employability, productivity, and support economic growth; and contribute toward the health and well-being of people and their communities. Inputs such as basic infrastructure, textbooks, and learning material can have a big impact on learning in developing countries. Books have been shown to be very cost-effective in improving learning, but only when used appropriately and integrated in instruction. DL4D was also found to be effective provided it was accompanied by teacher training and integrated in the curriculum.

Aker, Ksoll, and Lybbert (2010) evaluated the impact of a mobile phone literacy program on educational outcomes in Nigeria. They found that there were improvements overall in literacy and numeracy test scores, but such improvements were stronger in younger populations. The findings suggest that simple and often less expensive technologies can offer sustainable learning opportunities to rural populations. Wagner et al. (2014) proposed an effectiveness framework for mobile use for literacy which addresses purposes, devices, end-users, and context.

Bando, Gallege, Gertler, and Romero (2016) conducted a randomized controlled trial to compare the cost-effectiveness of delivering content between laptops and textbooks in 271 poor schools in Honduras. Their research showed no significant difference in learning gains. However, they found that substituting a total of five traditional textbooks with digital ones rendered the computers more cost-effective than textbooks for providing learning content.

Kremer, Brannen, and Glennerster (2013) conducted a literature review to examine the challenges of education and learning in developing countries. They found that some strategies are more effective than others in improving learning, and that some approaches are more cost-effective. They found that technology has the potential to improve pedagogy, management, and accountability in developing countries. A lot of the research they reviewed showed

that "providing more-of-the-same educational inputs without changing pedagogy or accountability typically has very limited impacts on test scores" (p. 297).

Programs using various pedagogical strategies and matching the level of instruction to the learner's needs have proven effective at improving learning. Banerjee, Cole, Duflo, and Linden (2007) found that a Mathematics computer-assisted learning program implemented in India focusing on supporting students learn at their own pace improved scores by 0.48 Standard Deviation (SD), or 1.54 SD per $100 spent. However, the work of Cristia et al. (2012) showed no significant improvement on academic achievement in Peru for the One Laptop Per Child Program, probably because of the lack of a solid pedagogical model, not aligning the program to the curriculum, and insufficient access to the internet. Providing education material for schools does not automatically improve learning. Several other factors are important for the success of DL4D such as professional development to improve pedagogy and assessment, providing support to match individual learner needs and characteristics, and a holistic approach to education planning and reform (Banerjee et al., 2007; Glewwe et al., 2009; Kremer et al., 2013; McEwan, 2015; Evans & Popova, 2015; Vrasidas et al., 2009).

McEwan (2015) collected 77 randomized experiments which examined the effects of school-based programs on learning in primary schools in developing countries, and conducted a meta-analysis to determine what works in improving learning. The author found that the largest effects came from programs involving technology:

> The largest average effect sizes are observed for treatments that incorporate instructional materials (0.08); computers or instructional technology (0.15); teacher training (0.12); smaller classes, smaller learning groups within classes, or ability grouping (0.12); contract or volunteer teachers (0.10); and student and teacher performance incentives (0.09). (p. 354)

It was also noted that most of the programs did not document costs at all, or at a level that would allow proper CEA. Within these constraints, the least cost-effective alternative was computer-assisted instruction in India (Banerjee et al., 2007) and the provision of textbooks in Kenya (Glewwe et al., 2009).

The conclusions of McEwan's analysis (2015) need to be read with caution because of the small sample sizes of some programs and the difficulty in accurately ranking and interpreting cost-effectiveness ratios. As the author explained, the CEA conducted was not based on primary data, and the meta-analysis could only report on the findings from the reports it included in the sample. All the studies listed and examined used varying measures and methods to document costs. For CEA to work, it needs to be designed properly at the beginning of the study with clear plans to collect effectiveness and cost comparison data (Levin & McEwan, 2001). Further, clear data should be collected from students and schools for both treatment control groups. Last, the cost-effectiveness ratio rankings should be read with caution because the large variety of objectives driving the programs implemented and evaluated do not permit proper comparisons of results.

One of the challenges of CEA is that treatments with similar effect sizes may vary regarding their real cost (Levin & McEwan, 2001; McEwan, 2015). As McEwan (2015) argued, it is misleading to use as the only criterion the effect size of an intervention in estimating its cost-effectiveness. One of the key issues in CEA is to collect the incremental cost of ingredients. From the analysis, the author found that "56% of treatments reported no details on incremental costs, while most of the rest reported minimal details" (p.

377). Some studies failed to document the exchange rates used to convert costs to a common currency, and how and if costs were adjusted for inflation.

Evans and Popova (2015) conducted a meta-analysis of six systematic reviews which examined what works in improving learning in developing countries. The results showed large discrepancies regarding which studies were included in the reviews, and how outcomes were interpreted. To examine all these studies, several approaches are used to synthesize findings, estimate effects, and provide recommendations. The six reviews they examined were studies by Conn (2014), Glewwe et al. (2015), Kremer et al. (2013), Krishnaratne, White, and Carpenter (2013), McEwan (2015), and Murnane and Ganimian (2014). These studies collectively reviewed 301 studies, among which 227 report learning outcomes, and 152 report enrolment or attendance outcomes. The scope of these reviews ranges from primary education to secondary education, and examine learning impacts and/or enrolment or attendance. All six reviews include studies conducted during the period 1990-2010 in sub-Saharan Africa, using randomized controlled trials focusing on learning outcomes in primary schools. One would expect substantial overlaps in the studies each review included. However, the analysis shows very divergent conclusions, suggesting a heterogeneity of effectiveness within categories of interventions. Evans and Popova (2015) noted:

> Of the 227 studies that look at learning outcomes, only three are included in all six systematic reviews, whereas almost three-quarters (159) are included in only one of the reviews. (p. 3)

They further noted that a lot of the variation in outcomes is captured within large categories, which can be misleading. For example, stating that ICT interventions are more effective is not as accurate and useful as stating that the use of technology supported learning, mapped to students' level and needs, aligned with the curriculum and with proper teacher training and support, and were most effective. Therefore, how can policymakers be informed with such divergent and sometimes contradicting findings? The results of these reviews say very little about the cost-effectiveness of various programs. This is an inherent problem in most of impact evaluations and studies published, since they do not report cost data.

In a recent report, the Results for Development Institute (2016) presented five examples of innovations attempting to scale and improve learning in the developing world. The case study examples come from Sudan, Brazil, Ethiopia, Ghana, and Peru. The costs reported for each innovation were not consistent, and as admitted in the report, without proper cost data; it is impossible to reach clear conclusions about the cost-effectiveness of interventions. The implementation in Sudan was based on Can't Wait to Learn (CWtL), a digital learning program for out-of-school children in conflict-affected areas. The program was based on a Mathematics self-paced game, which kids played using solar-powered tablets, with some support from local facilitators. According to the report:

> Initial projections put CWtL costs at-scale in Sudan at US$75 per year, per student, which is currently covered in its entirety by donor funding. This per-student annual cost is nearly US$100 lower than the US$172 annual unit cost of public primary school in Sudan. As it scales, the program's dropout rates and the number of beneficiaries reached will affect the final cost per student. (p. 31-32)

Developing the game accounted for 79% of the total costs of the program. Although this is a one-time cost, localization and development costs would be substantial if the program is to be adapted in other contexts and countries.

5

CHALLENGES IN USING CEA IN DL4D

The literature on CEA and DL4D has identified several challenges (Belfield et al., 2013; Dhaliwal et al., 2012; Evans & Popova, 2015; Levin & McEwan, 2001; McEwan, 2015; Results for Development Institute, 2016; Trucano, 2005). One limitation of CEA is that it reduces the impact of a program to a single measure or ratio, which can be misleading, particularly when the learning is strictly measured with tests. Another challenge relates to how researchers measure impact. Attributing outcomes to one specific program or intervention is a very difficult task. Schools are complex structures and there are numerous factors influencing impact, which can rarely be explained by one single factor. The benefits from programs often are multifaceted and often have spillover effects that are difficult to account for and measure (Jimenez & Patrinos, 2008).

Lewin and McEwan (2001) argued that one of the main challenges of using CEA is that evaluators can only compare cost-effectiveness ratios among programs that have similar goals. The authors argued:

> One cannot compare alternatives with different goals (e.g., reading vs. Mathematics or education vs. health) nor can one make an overall determination of whether a program is worthwhile in an absolute sense.

Some additional practical challenges for CEA, as discussed by Belfield et al. (2013) and Trucano (2005), are as follows:

- Understanding that costs listed on the budget of a program do not reflect the actual costs of the implementation of the program.
- Understanding that costs are estimates and it is difficult to get the exact cost of an intervention.
- Defining standard prices to avoid over- or undercosting an ingredient.
- Convincing evaluators to collect cost data, and collect them simultaneously with the effectiveness data.
- Obtaining accurate estimates of staff costs without overloading staff with the task of detailed time tracking and filling timesheets.
- Obtaining accurate estimates of all expenses, some of which are based on self-reporting.
- Estimating the total cost of ownership of ICT, particularly in the case of scale up.

Meanwhile, methodological challenges faced while conducting CEA (Belfield et al. 2013; Levin & McEwan, 2001) are as follows:

- Programs can only be compared if they measure at least one outcome in common. It might be that programs have similar goals, but one might have larger goals.
- Some programs might have multiple outcomes that go beyond the one compared; thus, the buying value of one is larger than the other.
- The impact of programs need to be measured using the same scale.
- Programs need to be thoroughly described and must be implemented with similar populations, contexts, and scale.
- Bringing together and combining costs and effect sizes from different sites is problematic since it might be biased towards certain kinds of settings and contexts (e.g., different SES, populations, implementation efforts, support on the ground).
- In cases of multiple sites of program implementation, it makes sense to present results per school, and then also for the combined group which will allow policymakers to select the analysis that best matches their situation.
- Calculating opportunity costs is not always feasible, particularly when not all cost data are available.
- The depth and analysis of costs and success factors will depend on resources available and the timeframe.
- There are many variables that will demonstrate varying cost-effectiveness results. Access to resources, socioeconomic status of students, past programs, and other factors will potentially demonstrate varying results. Given the limitations of the design, any interpretation of findings will need to be done with caution.
- Most programs and interventions are implemented on top of existing programs. Therefore, results are based on incremental costs and incremental effects. This needs to be considered when calculating and comparing costs.

There is very little work reported regarding the cost-effectiveness of DL4D. When not all data are available, evaluators can focus on conducting thorough cost analysis, documenting costs and impacts, and presenting all details needed for readers to reach their own conclusions regarding the applicability of the findings to their local contexts.

6

ADDRESSING THE CHALLENGES OF CONDUCTING CEA IN DL4D

CEA alone does not offer sufficient information for decision-makers to allocate funds to programs. Investments in education should not be driven strictly by costs and cost-effectiveness ratios. As Jimenez and Patrinos (2008) argued, "education investments are worthwhile to do for non-economic reasons and in that case, policy analysts need only ensure that it is provided at least cost" (p. 25). What is missing from global efforts to education is the appropriate emphasis on sustainable program design and implementation with ICT (Passey et al., 2016). The aspects of scalability and sustainability need to be addressed if DL4D is to contribute toward quality education for all.

According to Levin and Belfield (2015), for results from CEA to be useful to policymakers, two key conditions must be met: rigorous data analysis should be applied in estimating cost-effectiveness, and data should be presented in simple and useful ways to policymakers. Policymakers do not always make explicit their expectations from a program they develop. It is important that decision-makers clarify their objectives, so that CEA can focus on providing the most relevant information to support them in reaching decisions to meet those objectives. When policymakers have a clear plan of what they want to achieve, CEA can aim to collect and analyze relevant data that will be the most useful for reaching such decisions.

Moreover, policymakers and government agencies need to be educated on how to use evidence from research and CEA to prepare policies and programs.

Some recommendations to address the challenges of conducting CEA for DL4D (Dhaliwal et al., 2012; Levin & Belfield, 2015; Levin & McEwan, 2001) are:

- Plan concurrent collection for both costs and effectiveness data.
- Compare programs that have similar goals and measures, and target similar populations.
- Use multi-site studies for evaluation to gain deeper insights on all costs and effects.
- Regarding cost estimation and prices, distinguish local from general or national prices.
- Accommodate new evaluation methods for both impact evaluation and CEA. Design-Based Research can contribute toward our understanding of what works in DL4D.
- Integrate in CEA studies some rich qualitative data collection and analysis, to shed light on the complexities of programs and

attach real world stories to the CEA ratios and numbers presented and discussed.

- Apply sensitivity analysis to test the robustness of results and examine possible parameters reflecting uncertainty, including effectiveness estimates, cost estimates, discount rates, and the like.

- Explore interdisciplinary research and learn from other disciplines (e.g. health) that have been applying CEA for decades.

- Work with decision-makers to structure the CEA to provide results that will be useful for them to develop policies and programs.

- When proper CEA cannot be conducted, analyze and discuss costs without necessarily making claims about cost-effectiveness.

- Provide transparency in all processes and actions during CEA. Detailed description of methods, tools, assumptions, limitations, contexts, measures, and validity of tools, among others, will allow policymakers, designers, and researchers to reach their own conclusions about what could apply to their own situation.

Further research is needed to better understand the complexities of conducting CEA for DL4D and allow policymakers to make informed decisions about interventions in the developing world. An important aspect of CEA is that most relevant research is based on strictly quantitative measures. In-depth ethnographic case studies of communities and schools can shed light on the complexities of DL4D in the developing world. Such studies can highlight the challenges of DL4D, identify potential effects which traditional methods and test scores fail to capture, facilitate more accurate cost estimation, and guide better decisions for fund allocation.

7

SCALABILITY AND SUSTAINABILITY OF DL4D

So far, we have established that ICT, when integrated properly, has the potential to improve the quality of education and improve access to education in an equitable manner. Research has shown that when designed properly, education programs focusing on DL4D can provide quality education to marginalized groups in developing countries (Aker et al., 2010; Bando et al., 2016; Banerjee et al., 2007; Burns, 2014; Cristia et al., 2012; Glewwe et al., 2009; McEwan, 2015; UNICEF, 2017; Vrasidas et al., 2009). One concern of governments, donors, and international agencies is scaling up successful programs. In this section, we discuss the elements of scaling up innovations in the context of DL4D and provide recommendations for policy and practice. Most research on scalability of education programs conceptualize scale in a unidimensional way, involving the expansion of the program to bigger numbers of schools, teachers, students, and regions. However, what is often ignored is that scaling up programs requires deep understanding of the challenges of managing change, reform, and distributed leadership across multiple levels and contexts (Dede, Hona, & Peters, 2005; Results for Development Institute, 2016).

UNICEF (2014) adopted nine principles for innovation and the design of technology supported programs for development. These are: 1) Design with the user; 2) Understand the ecosystem; 3) Design for scale; 4) Build for sustainability; 5) Be data driven; 6) Use open data, open standards, open source, and open innovation; 7) Reuse and improve; 8) Address privacy and security; and (9) Be collaborative. These principles have been adopted by many agencies around the world, including USAID, the Gates Foundation, WFP, WHO, and UNHCR.

Robinson and Winthrop (2016), in a recent report, examined in-depth case studies of how scale-up of learning initiatives took place in countries like Brazil, Uganda, Jordan, and India. They found that successful scaling takes place when new ideas develop on the margins and spread to reach more stakeholders. This requires flexible governance,

allowing flexibility to local stakeholders to try, fail, and learn. Lessons must be documented and capitalized upon to allow for programs to scale. Delivering and scaling up programs require a set of both technical and political actions which include the following:

- Build strong education partnerships: all stakeholders need to collaborate toward an agreed vision.
- Identify and use learning champions and leaders both at the political and classroom levels.
- Use appropriate, context-sensitive, and relevant technologies which can accelerate progress.
- Align programs with country needs and priorities.
- Evidence-based decisions and data on costs and effectiveness can facilitate appropriate decision-making.
- Provide opportunities for flexible financing to establish core operations capacities.
- Middle phase financing is essential to bridge the stage when moving from pilot to large scale.
- Financing should be flexible, including building core operational capacity.

8

SYSTEMATIC, SYSTEMIC, AND SUSTAINABLE DL4D

Between 1997 and 2017, we designed, implemented, and evaluated with colleagues more than 150 digital learning projects in more than 30 countries. The results of those studies led to the construction and refinement of the 3-Sigma framework (systematic, systemic, and sustainable) for the adoption and potential scale up of education innovations (Vrasidas & Glass, 2002, 2004, 2005; Vrasidas et al., 2009; Vrasidas 2015). Considering the research discussed thus far, we revised and adapted this framework to provide a conceptual tool to help policymakers think through the main factors they need to consider in designing DL4D. This framework is neither a recipe for success nor a tool that will solve all problems regarding scaling up DL4D. It is rather a summary of some of the key knowledge we acquired about DL4D through research and practice.

First, programs to succeed and have the potential to scale up need to be designed and implemented in a systematic, methodical, and structured way based on evidence, local needs, and resource availability. Second, programs need to address the multiple and systemic issues of education (e.g. curriculum, assessment, teacher development, and infrastructure), following a holistic approach. Third, they need to be designed for sustainability with proper design, planning, and support systems in place.

The research discussed in this paper clearly shows that DL4D is influenced by numerous factors including stakeholder engagement, needs and characteristics, infrastructure and ICT availability, support structures, cost-effectiveness considerations, leadership at local and country level, teacher practices, curriculum, pedagogy, assessment, and teacher professional development. All these factors are embedded in an education structure with specific policies and strategies at the local, regional, and country levels. This education structure is then embedded in a broader cultural context with specific socioeconomic, linguistic, geographical, and historical backgrounds. Figure 2 is an attempt to portray this framework. Ongoing monitoring, research, and evaluation should be used to constantly feed evidence back into the program. This framework attempts to summarize some of the key issues regarding the implementation of DL4D, and it was fine-tuned by conducting a literature review, the majority of which were already discussed in this paper (Altunate & Nussbaum, 2013; Compernolle & Visser-Valfrey, 2011; Cooley & Linn, 2014; Cristia et al., 2012; Cuban,

2001; Kleine et al., 2014; Kleine, 2013; OECD, 2015; Results for Development Institute, 2016; Robinson and Winthrop, 2016; Trucano, 2005, 2013).

Further, it is important to develop a culture that supports and sustains research and evaluation in education which can offer evidence-based solutions to problems (Cooley & Linn, 2014; Dede et al., 2005; Robinson and Winthrop, 2016; Vrasidas et al., 2009). This can be supported by:

- Embedding ongoing monitoring and evaluation in all programs, and collecting both impact and cost data throughout the implementation and scale up.
- Documenting and measuring learning, defining what works, identifying successful programs, and using lessons from these for future planning.
- Establishing communities of practice and knowledge hubs to allow multiple stakeholders to share and discuss lessons learned across contexts, regions, and countries.

It is relatively easy to offer enough support for pilot implementations to be successful, compared to the challenges of large scale implementations. However, unsuccessful pilots are often rarely reported. The education community can learn a lot from unsuccessful implementations of programs. There are diverse reasons why many projects fail to scale up. Such include the lack of initial planning, lack of strong results at the pilot stage, failure to match pilot objectives to region and/or country-wide priorities and needs, and lack of resources. Further research is needed to better understand the complexities of conducting CEA for DL4D and issues affecting scalability and sustainability of programs.

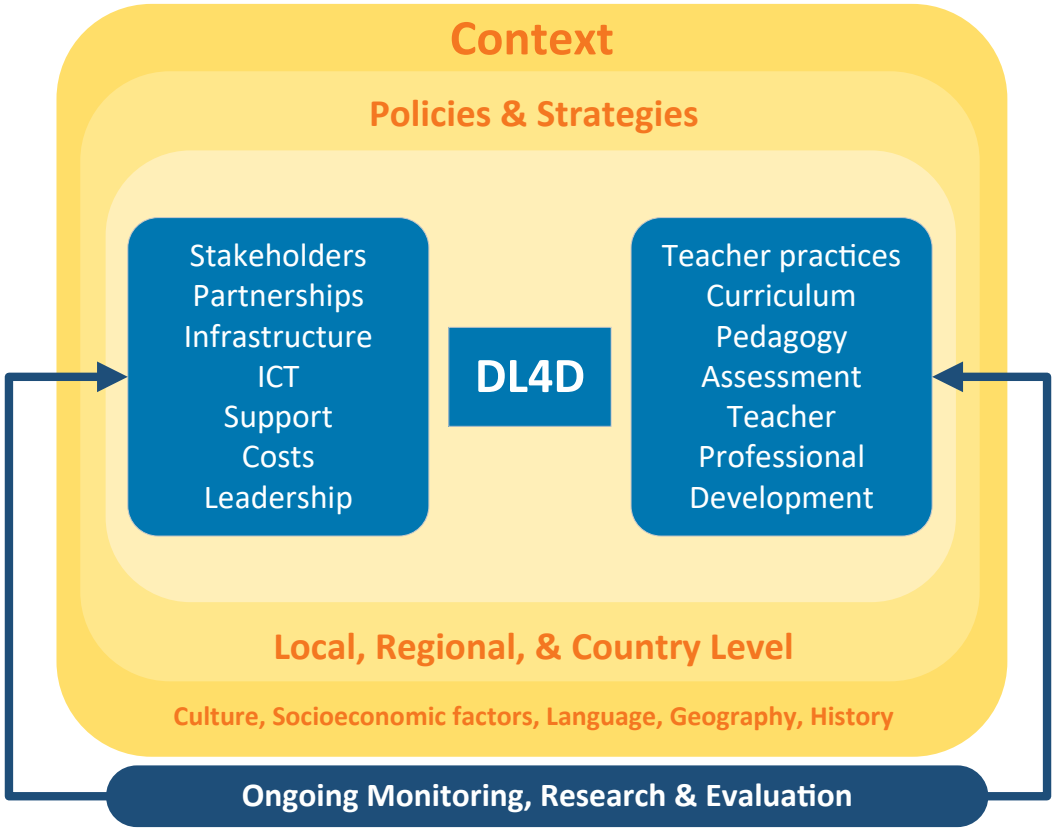

Figure 2. *A framework for Systematic, Systemic, and Sustainable innovations in education adapted for DL4D.*

9

POLICY AND PRACTICE IMPLICATIONS FOR THE GLOBAL SOUTH

Establishing the cost-effectiveness of programs is a political process during which priorities are established and value judgments are made regarding program costs and effects. Program evaluators, governments, and funding agencies act within specific ideological frameworks which inform the decisions they make regarding to what to evaluate, what to measure and what not, and what to compare among programs. The research on effectiveness of learning interventions carries a strong ideological assumption with a strong positivist philosophical perspective. As a result, cost-effectiveness has been reduced to a number: a ratio which strips away any relevant information relating to context, complexities of classrooms, communities, and culture. In the Global South, using cost-effectiveness data to make decisions regarding resource allocation for DL4D becomes even more important when children do not have basic needs addressed such as nutrition and healthcare.

Making decisions for DL4D to scale is not an easy task. It is important that projects are designed to be run in pilot format and with smaller targets, but with scalability in mind (Kleine et al., 2014). Multiple iterations of pilot projects might be needed to fine-tune all issues and examine the feasibility of scale. Given the diverse contexts of countries and cultures in the Global South, solid planning for pilots and scaling are essential. Further, programs need to be planned carefully to allow for solid cost and effect comparisons. When designing programs, there is the tendency among agencies and implementers to start where there most likely would be success. For example, implementation might start with a well-equipped school in an urban setting with sufficient resources and quality teachers. However, pilots should be run to include both rural and poor schools with limited resources, particularly when a large percentage of schools are from these areas. Some key questions that policymakers, program designers, and practitioners in the Global South need to consider (Bradach, 2003; Cooley & Ved, 2012; Cooley & Linn, 2014; Dede et al., 2005) when designing DL4D programs, conducting CEA, and making decisions for scalability and sustainability of programs are:

- What are the priorities in the specific country, region, and community in which the program is targeted?
- What is the added value of technology?
- Can the same impact be achieved more effectively without ICT?

- Who are the key stakeholders and how can we build a solid partnership?
- What are the costs for scale up and what is the potential impact?
- Does the program present a solid theory of change and has strong initial outcomes?
- What is an appropriate scale of the program?
- Are the mechanisms for documenting and tracking performance and data collection in place?
- What are the potential obstacles and risks and how can they be addressed?
- Are the resources for scaling the program available?

Designing DL4D programs following a systematic, systemic, and sustainable framework requires a collaborative approach where stakeholders are engaged early in the process and strong partnerships are established at the local and regional levels. Engaging all stakeholders will help build shared ownership of the program. Building strong partnerships is essential to provide the means and resources needed. However, managing multiple stakeholders and partners requires sustained effort and flexible strategies which can lead to increased costs. Understanding the context and building a strong ecosystem to accommodate the scale-up of quality DL4D programs require a clear vision informed by evidence, and with all the resources and support mechanisms in place. Scaling up also requires that all stakeholders involved have the necessary skills to support the program. Strong emphasis should be placed on supporting local stakeholders and building their capacities for sustaining the program.

10

CONCLUSION

In times of financial crisis, large investments in technology and infrastructure come under scrutiny. Looking at international studies, there are reasons for the limited use of ICT and impact of DL4D, other than the simple lack of equipment. These reasons are difficult to address. The true value of CEA is its ability to take a complex program and summarize it into a simple ratio of effects to costs, making it easy to compare to programs addressing similar goals and needs (Dhaliwal et al., 2012).

However, CEA is just another tool and should never be used in isolation; it should be combined with other indicators and tools in reaching decisions about program design, implementation, and scaling. A critical frame of mind toward the possible benefits and challenges of using CEA for DL4D is required. The critical use of CEA in DL4D opens opportunities for research, development, and evidence-based policy-making that are much needed.

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ACKNOWLEDGEMENTS

I would like to thank Dr. Tassos Kyriakides from the Yale Center for Analytical Sciences and Mr. Demetris Hadjisofoclis from INNOVADE for the valuable feedback and comments they provided during the preparation of this paper.

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