DL4D
DIGITAL LEARNING FOR DEVELOPMENT

The Cost-effectiveness of Digital Learning: Lessons from Educational Experiences in Africa

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INTRODUCTION

African societies are grappling with the linked challenges of globalization and the impact of the proliferation of information and communication technology (ICT) on the changing requirements of work. The pace of technological change and the accompanying ICT disruption require new approaches to knowledge, skills, and competence. It is becoming increasingly important to develop new systems of education. Simultaneously, African education systems are under pressure to increase enrolments to accommodate burgeoning social demand for education opportunities. This places pressure on physical facilities, human resource capacity, and institutional budgets, and creates struggles in accommodating the growing demand while maintaining high levels of teaching and learning quality (Mohamedbhai, 2011). In this context, digital learning is increasingly considered as an option in tackling various challenges in education and in ensuring that education provision remains relevant.

ICT in education has gained prominence in Africa since the early 1990s. In South Africa, the Technology-Enhanced Learning Investigation of the South African Department of Education (2004) took place in the early 1990s, and led to the establishment of the South African White Paper on e-Education. This policy, published in the Government Gazette in 2004, was lauded the most comprehensive policy on ICT in education in the continent, although very few of its policy objectives were achieved. Since then, several organizations and initiatives have done substantial work and research in ICT in education. These include the Association for the Development of Education in Africa's Working Group in Distance Education and Open Learning (Butcher, 2003), eLearning Africa, infoDev, Commonwealth of Learning, Nepad eSchools initiative, UNESCO (2015), e-Transform Africa (2012), Agence Française de Développement, and Agence Universitaire de la Francophonie (2015), among others.

Since the first initiatives to use ICT to support education systems, there have been debates about the cost-effectiveness of harnessing digital learning. Such debates have tended to reveal more the agenda of the participants than answers to the question itself. In part, this is because such initiatives are driven by multiple competing imperatives – political, economic, financial, and social – and not purely by educational objectives. However, it is also in part because the issue of cost-effectiveness depends on several different variables. This paper thus first considers some of the challenges in defining digital learning and the political challenges in measuring cost-effectiveness. It then focuses on issues of cost-effectiveness using examples from three initiatives: the Nepad e-Schools Total Cost of Ownership (TCO) financial modelling tool, the adaptation of the UNESCO ICT Competency for Teachers (CFT) professional development course for teachers, and the South African Institute for Distance Education (SAIDE) Facilitating Online Learning course (FOLC). Finally, this paper outlines a few key lessons in the cost-effectiveness of digital learning initiatives in Africa.

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THE CHALLENGE OF MEASURING COST-EFFECTIVENESS OF DIGITAL LEARNING

Wikipedia (n.d.) defines digital learning as:

> Any type of learning that is facilitated by technology or by instructional practice that makes effective use of technology. It encompasses the application of a wide spectrum of practices including: blended and virtual learning.

This can include any or a combination of adaptive learning, badging and gamification, blended learning, classroom technologies, digital textbooks, learning analytics, learning objects, mobile learning, personalized learning, digital learning, open educational resources (OERs), technology-enhanced teaching and learning, and virtual reality. This list illustrates the impossibility of determining if digital learning is cost-effective, as it has become a catch-all phrase for a very broad range of educational practices using technology in different ways. Thus, a possibly obvious but essential qualifier is that it is not possible to determine the cost-effectiveness of digital learning, given the almost limitless kinds and combinations that exist. This problem is exacerbated by the reality that most forms of digital learning include permutations of distance or face-to-face contact between educators and students.

This problem is further exacerbated by the meaning of cost-effectiveness. Hoosen and Butcher (2017) provided definitions of cost-efficiency and cost-effectiveness to differentiate the two:

> Cost-effectiveness refers to the extent to which an institution or programme produces particular outputs (which are concrete and measurable) or outcomes (which may not be measurable). It represents striking the optimal balance between cost, student numbers and educational quality, a balance that changes according to educational context.
>
> Cost-efficiency refers to the extent to which an institution or programme maintains a particular level of production with fewer resources or increases the level of products or services it produces with a less than proportionate increase in the resources used. It thus refers to the 'cheapness' of educational provision. (pp. 186-187)

In theory, measuring the cost-efficiency of a digital learning initiative should be relatively simple if the level of production maintained is clearly defined and can be compared before and after the introduction of the initiative. In practice, however, this is almost impossible to achieve because of complex variables at play. Typically, a digital learning initiative will require investments of some kind in ICT infrastructure (hardware, connectivity, and/or software); digital content development and/or procurement; professional development of educators, education managers, and/or students; and policy, procedural, and/or regulatory changes. Almost inevitably, this will lead to changes in what is being produced, which makes the before and after cost-efficiency comparison very difficult. This becomes increasingly complex because investments in technology typically comprise both some initial investments and a series of ongoing costs, many of which only become apparent after the initiative has been running for some years.

A qualitative assessment of cost-effectiveness − which relies on judgments of the researcher as to whether an optimal balance is being struck between costs, student numbers, and educational quality − is difficult in practice. This is primarily because digital learning innovations are often predicated on an assumption that there is a need for education systems to change in response to emerging technological and social imperatives, for example, the need for different kinds of skills in a knowledge society. In these cases, one rationale behind the introduction of digital learning is to change the learning outputs or outcomes. This makes comparisons of cost-effectiveness before and after the introduction of digital learning difficult, if not impossible. As technology is often used to change the learning experience and the learning objectives, one is not comparing things that can be reasonably compared. In a context in which investment in technology is intended to change not only how the system functions but also what it delivers, traditional comparative economic analyses provide no clear insights. As highlighted by Cawthera (2001):

> Undertaking such research is also exceptionally difficult. The learning outcomes from computers in schools may be different from those achieved with other inputs, making comparisons difficult. Furthermore, in education the links between inputs, processes and outcomes are difficult to isolate and measure. Even when proxies for these are obtained there is no guarantee that perceived relationships in one situation will hold in another. While trends give useful insights, context is also critically important. When the cost element of the cost-effectiveness equation is inserted, drawing conclusions is even more difficult. (p. 10)

While there is substantial literature on how to conduct cost-effectiveness and cost-benefit analyses, there are considerably fewer available resources providing economic analyses of digital learning initiatives in Africa. Further, there is no right methodology for such analyses, and while there have been efforts to consider cost-effectiveness for application in education (e.g., Dhaliwal et al., 2012), there are few resources tackling the cost effectiveness of digital learning.

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THE POLITICAL DILEMMA OF MEASURING COST-EFFECTIVENESS

A World Bank study (2018) found that much of whether initiatives get implemented also depends on the political climate:

> Politics can intensify misalignments in education systems, when the vested interests of stakeholders divert systems away from learning. (p. 189)

Political engagement with digital learning often focuses on the technology itself, assuming that rolling out technology into education systems is a meaningful proxy for deeper systemic changes needed to respond to many current educational challenges. Such changes might include both curriculum reform and re-skilling educators to equip them to prepare their students for the rapidly changing world of work. Both are essential but neither is necessarily dependent on digital learning for success.

Further, many ICT in education initiatives are driven by a political imperative to distribute devices to institutions and students to garner short-term political support, rather than to improve educational outcomes. This is seen in several laptop initiatives, many of which have had to deal with allegations of corruption and political opportunism. For example, in Kenya, one of President Uhuru Kenyatta's incoming election pledges was to supply 1.2 million laptops to first year primary pupils – a $600 million project, with a $100 price tag per laptop. However, the first round of tendering was cancelled, as the initial quotations were far higher than $100. In Nigeria, the government ordered a million laptops to be distributed to schools in 2006, but with a change in administration in 2007, government priorities shifted and the initiative was abandoned (Mungai, 2015).

Rolling out digital learning initiatives on a large scale is an expensive endeavor, and costs incurred during pilots do not accurately predict what will happen when the initiative is rolled out at scale (Trucano, 2013). In African contexts, such investments, when made at all, are typically made in circumstances where there are often funding shortages across the entire system. Thus, a decision to invest government education funds in technology, while politically appealing in the short term, leaves decision-makers susceptible to criticisms of wasting resources should the investment prove to be a failure. Given existing resources constraints and lack of adequate technical, commercial, and human infrastructure support, widespread and ubiquitous uses of ICT in education are not regarded possible in most developing countries (InfoDev, n.d. a). Additionally, the complexity of digital learning investments, especially in public education systems which are known to be resistant to change, means high prospects of failure.

Under these circumstances, it becomes appealing to focus on rollout of technology to meet political promises of hardware delivery irrespective of whether the process demonstrates educational benefit. Such politically-driven initiatives are allocated special, one-off budgets, which are used to procure technology and connectivity, do marketing, train educators, and sometimes develop content. This lack of integration of ICT budgets into the annual operating budgets of the education system generally makes the initiative unsustainable in the long run, as little consideration is given on how technology will be replaced and maintained, connectivity costs sustained, teacher and principal professional development continued, and the services of full-time personnel within the Ministry of Education retained, among other ongoing costs. In these situations, it is highly likely that promised cost-effectiveness gains of digital learning will not materialize.

Given these realities, it is unsurprising that political decision-makers are reluctant to allow fully-fledged cost-effectiveness research into digital learning initiatives, even when it is widely understood that education systems reform is essential. The level of investment required, combined with complex variables that impact on the effectiveness of that investment, make systematic financial assessments of such initiatives too risky to commission. Without political support, proper cost analysis of digital learning initiatives implemented at a large scale are not possible to conduct with any meaningful degree of accuracy. As a result, despite many thousands of pages of text having been written on digital learning initiatives in Africa, including many process evaluations of those initiatives, there remains a dearth of reliable data available to provide clues about the potential for digital learning initiatives to be cost-effective.

The lack of credible data related to the costs of using ICT to support education and the cost-effectiveness of ICT initiatives is a major challenge (InfoDev, n.d. b). Even where cost studies exist, there is greater focus on the initial costs of introducing ICT than on the real costs of implementing and maintaining ICT over time, and on subsequent analyses of the estimated return on this investment (InfoDev, n.d. a). One example in the African context is the study by Cawthera (2001), which considered issues of costs in developing countries, with original data from South Africa and Zimbabwe. The study found that the best way to lower the unit costs (i.e., the cost per student) is by increasing usage of the equipment provided. Further, the cost of providing hardware and software is only a part of the total cost of provision over a five-year period. The study also highlighted the need for appropriate benchmarks and ratios to be developed to assist in the planning of computer provision and assess the efficiency of usage once computers have been provided. Another example is the survey by Paterson (n.d.) of total costs of owning computer rooms in 62 schools across Botswana, Namibia, and the Seychelles. The study considered costs associated with installing software, hardware, and peripherals in school computer rooms, as well as recurrent expenses, human resources, training and management, and administration costs. The study found that in Botswana and the Seychelles, where governments provided computer facilities to all post-primary schools, ICT expenditure per school was much higher than in Namibia, where school computer facilities are funded from several sources, including the government, non-government organizations, and the community. The same study argued that high expenditure is not necessarily associated with efficiency of resource usage, and that internationally-benchmarked research is needed to support decision-making and reduce risk in allocating resources. Aside from these resources, there is little research on the costs of ICT in African schools.

Given this lack of reliable data on costing, and the above-mentioned challenges, this paper attempts to reflect on aspects of cost analysis in digital learning initiatives and outline some proposed approaches that might be useful to conduct such research in future.

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COSTING DIGITAL LEARNING INITIATIVES

Given the wide range of options that digital learning encompasses, related costs differ according to the type of initiative. Digital learning initiatives are typically of two kinds: some are small scale and limited to one, two, or a few institutions, while others are large scale and start with several institutions, typically with a view to scaling the intervention across a national or at least provincial education system.

This paper considers two types of initiatives: 1) a large scale continental financial modelling initiative focusing on the set up of digital learning; and 2) two smaller scale initiatives focusing on course design and content development, revision, and remixing.

4.1 Costing a large-scale initiative

An example of a planned large-scale digital learning project is the Nepad e-Schools Initiative, which aimed to impart ICT skills to young Africans in primary and secondary schools, and to harness ICT technology to improve, enrich, and expand education in African countries. As a key step in taking the initiative forward, Ernst and Young, and Neil Butcher and Associates (NBA), were enlisted to provide planning support to ensure that the Nepad e-Schools Initiative was rolled out in schools across Africa effectively and in a sustainable manner. This was done by developing a comprehensive business plan and a series of planning tools and frameworks to assist participating countries to develop and improve their own national plans (E-Africa Commission, 2007a).

One aspect of these efforts was to develop a total cost of ownership (TCO) financial modelling tool to support the Nepad e-Schools business planning process. The tool enabled users to define a series of business planning inputs such as the scope of the project; timing of project rollout; economic parameters such as currency conversion rates and annual inflation rates; operational assumptions that map scale of rollout; and assumptions related to professional development, governance and operations, policy development, content development, and research and evaluation. The tool also allowed users to define a series of technological and professional development models relevant to their planned implementation strategy.

Using this model, the authors presented a projection of the total cost of ownership of rolling out computer infrastructure into 600,000 schools across 52 countries in Africa over a period of 10 years. The model and costs underwent a consultative process and were regarded by all concerned to present a comprehensive and accurate perspective on the full costs associated with rolling out digital schooling in Africa. The budget included consideration of: 1) capital expenditure (technology); 2) capital expenditure (infrastructure); 3) insurance (technology); 4) maintenance (technology); 5) professional development; 6) governance and operations; 7) policy development; 8) research; 9) content development; and 10) marketing, advocacy, and reflection.

In addition, a rural cost weighting was applied, considering the additional costs involved in working in remote and rural environments. Running costs for both technology and security were calculated, and a monitoring and evaluation budget was included as a percentage of overall expenditure (E-Africa Commission, 2007b).

This exercise was largely hypothetical given varying national contexts. The TCO model was a flexible resource, allowing all assumptions to be altered, thereby letting users conduct ongoing modelling exercises. In this process, the user first defined the items to be used in all the models. This included computer equipment; network equipment; communication equipment; other equipment like photocopiers, audio visual tools and so on; content and applications; infrastructure; running costs; professional development; and governance and operations. The user was able to assign the asset life, insurance category, and a series of associated running cost for each component. The user was then able to define a series of models comprised of various combinations and quantities of the model components. To define each model, the user would select the component to be included, and indicate the number of this component that already existed in the system, as well as the number of new items required. This enabled the user to use the tool to develop upgrade models for different aspects of the technology. Finally, the user could define a roll out plan. In so doing, they were required to specify the percentages of each models to be applied to the population of schools, as well as the pace at which these would be implemented over the ten-year period.

The financial modelling tool provided a global budget and associated annual budgets. In addition, a quantity list for the total number of components required in each year of the plan was generated. The model highlighted that the costs do not reflect an amount that would need to be raised by a project to provide for rollout. Different costs would need to be absorbed at different levels (i.e., continental, regional, and national) and by different players (i.e., governments, private sector, donors, and civil society). The following examples show how such costs might be managed effectively:

- Negotiating preferential educational telecommunications rates with telecommunication providers to reduce the financial burden of providing internet connections for each school
- Negotiating lower costs of equipment and software with the relevant private sector companies in rolling out infrastructure
- Providing refurbished equipment which could reduce the capital expenditure bill, although will increase project management and maintenance budgets
- Requiring companies winning infrastructure bids to absorb some of the costs of professional development
- Expecting schools to incorporate maintenance and some running costs in their budgets, for example, running costs of printers, monthly telephone bills, costs of insurance, and maintenance of equipment
- Persuading local IT and other companies to adopt-a-school to reduce maintenance budgets

- Increasing the cost of professional development which might lead to maintenance savings, for example, the provision of A+ courses to school employees which could enable maintenance work to be done by the school, rather than having to pay additional costs for such work

While the TCO model provides a useful guide to the expected costs of rolling out digital learning, it is difficult to measure the cost-effectiveness of the model in practice, as its effectiveness is influenced by several factors. For instance, a challenge occurs when the rollout of ICT comes to be perceived as a policy priority in its own right, rather than as a tool to help to solve specific educational problems. In this case, an ICT in education policy may be viewed as a "symbolic gesture" (UNESCO, 2015, p. 8), teachers may resist change, there may be no explicit connection to instructional practice, or there may be a lack of program and resource alignment to policies. When this happens, ICT investments end up being layered on top of education systems as an additional expense, without driving any other changes in educational practices or creating any new systemic efficiencies.

Nevertheless, the Nepad TCO model provides an example of a large-scale financial modelling tool that might form the basis for analyzing the full costs of digital learning initiatives on a large scale. If these can be compared with educational improvements and subsequent economic effects derived from such investments, even if only speculative, then this could potentially form a basis for assessing the relative cost-effectiveness of digital learning.

However, measuring educational improvement depends on the aims of the digital learning initiative. Examples of these are: 1) making reforms to student outcomes; 2) changing instructional/teaching strategies; 3) changing approaches to assessing student outcomes; 4) providing access to learning resources, for example in multiple languages; 5) improving student retention in subjects such as Mathematics and Science by making the content more relevant; and 6) introducing cooperative learning or self-directed learning.

Depending on the aim, the measurement of educational improvement will vary. For example, if the aim is to change instructional strategies, the initiative may involve the introduction of mobile technology tools to enable learners to collect, create, transform, and adapt their own learning materials. These tools can be used for collaborative learning, group work, projects, problem-solving, and creative thinking. The success of such educational improvement can be measured by: 1) improved student retention in the specified subject; 2) higher-education-enrolment rates; 3) frequency of ICT use; 4) increased competencies in specified skills; 4) reports on student and teacher experience in using ICT; and 5) improvement in digital competencies for teachers.

Cost-effectiveness research will compare the projected cost with expected educational gains to be able to determine cost-effectiveness potential. What is included will depend on what the cost-effectiveness analysis will be used for, and by whom.

Conversely, small-scale initiatives typically focus on the institutional level and might include developing digital learning modules, investing in learning management systems (LMS) and related online learning platforms, or using specialized assessment software to facilitate online, mobile, and blended learning. In these instances, each technology option considered has its own cost structure and implications. One example that is relatively easier to measure is course design and development using digital technology. The next section focuses on an example of such an initiative using OER.

4.2 Costing for course design and development

Educational institutions pursue effective teaching and learning, which require appropriate investment in curriculum and course design, materials development, ongoing evaluation, and regular curriculum revisions and course design. Because these costs can be tracked and managed, they are often most often studied. Course development is a fixed cost incurred by education providers regardless of the number of students who study the course. In addition to fixed costs, there are ongoing costs such as updates and additions to course materials or course revisions, depending on the volatility of the material. Course design, renewal, and remediation are potentially sources of considerable expenses, since it is always possible to add more person-power to course design teams or seek more expensive media and technologies.

Several factors impact on the costs of course design and development. First, the level of instructional design, where the more design, the higher the quality of the course, but also an increase in time and cost. Increasing interactivity in courses typically requires more time and often more specialists to develop the content and methods (Boettcher, 2006; Mays, 2011).

Second, the amount of media richness − videos, graphics, simulations, and interactive exercises − that will be included, where an increased richness can translate to better instructional outcomes and less need for direct instructor involvement in course delivery, but will also increase cost and development time.

Third, some production tools for video and multimedia have become both cheaper and more readily available. While video and simulations may be more expensive to produce than printed resources, they can be more cost-effective in contexts when practical demonstrations are required. The same content can be used to teach successive cohorts and increasing numbers of students over a period of several years, provided the design allows for easy amendments and updates to the content and envisaged use in a range of applications and markets. Videos and multimedia presentations are particularly useful and likely to generate cost savings where the content is unlikely to change for example, in trades such as bricklaying (Hoosen & Butcher, 2017).

Fourth, the number of people who work on course development, where the more people involved, the faster the development, but the higher the cost.

Fifth, the type of staff who do the work; in a higher education institutional setting, faculty members, graduate students, professional designers, and developers have different skill levels for course development and different hourly rates. Specialized staff can get the job done more quickly and with higher quality, but will cost more (Center for Educational Innovation [CEI], n.d.). Historically, the functions required in curriculum and courseware design have tended to be spread across multiple specialists, thus raising the costs. However, as course developers become more experienced and comfortable with the available tools and technology, the number of hours required to produce content should decrease. They may become multi-skilled, capable of combining the functions of instructional designer, graphic and web designer, and general editor. Such multitasking is being greatly facilitated by the growing number of ICT-based content development tools (Raccoongang, 2018).

Sixth, the role of the instructor or faculty member, where the more roles instructors fill compared to instructional design professionals, the lower the external costs. The trade-off is the increased opportunity costs as the faculty are not able to use the time for other work. Because not all faculty possess the skill-sets needed for instructional design and development, instructional outcomes may not be as positive.

Seventh, the implicit costs involved in institutions with in-house instructional designers and developers, where design and development costs are not made explicit. In these units, there may not be a specific amount paid for design and development costs. In other instances, development costs are subsidized by an academic technology unit, made available through central services, or paid for directly on a fee-for-service basis.

Eighth, whether materials have already been developed for a face-to-face course; some digital learning involve taking the existing text-based materials instructors have produced for a face-to-face class and loading them into Moodle for blended or online delivery. In this model, there is little or no instructional design employed to convert the classroom-based course. A blended or online course produced in this manner would require about 60-80 hours (CEI, n.d.).

There have been several attempts to estimate the costs involved in course design and development. The University of Minnesota estimates that the number of hours required for course design and development covers a wide range from 70 to 600 hours, with an average of about 250 hours (CEI, n.d.). A 2017 survey by Defelice (2018) looked into how long it takes teams to typically design and develop one hour of teaching, the results of which are summarized in Table 1.

TYPE OF TRAINING (per 1 hour)	**Number of respondents**	**Total Hours**	**Average**
Traditional	136	5,175	38
Live, Instructor-Led (Virtual)	87	2,450	28
E-Learning/Level of Interaction			
Level 1: Passive	87	3,693	42
Level 2: Limited	88	6,266	71
Level 3: Complex	53	6,864	130
Level 4: Real Time[1]	21*	2,997	143

Table 1. *Time taken to develop one hour of training*

[1] *The presented average for level 4 should be interpreted with caution as it is based on the input of 21 respondents.*

Several factors determine time estimates, including the number of years of experience of the developer and whether they have specialized skills; the developer's environment and whether they work for an internal team or a vendor; the type of technology they are using; the type of learning content being developed; and who the client is and their level of involvement (Defelice, 2018). It has also been argued that online course design and development costs depend heavily on the instructional design model chosen; a blog by Raccoongang (2018) estimated how long it takes to develop an online course, noting that the online course design and development costs depend heavily on the instructional design model chosen. The study described the ADDIE model, a generic process traditionally used by instructional designers and training developers, whose five phases – Analysis, Design, Development, Implementation, and Evaluation – represent a dynamic and flexible guideline for building effective training and performance support tools (Raccoongang, 2018). The role of each team member was considered and identified in the model as: course owner, subject matter expert, project manager, instructional designer, marketer, lecturer, psycholinguist, graphic designer, director, video operator, video editor, and content manager. Each of these team members was involved in various stages of the course creation: design, development, market analysis, and implementation. The study estimates that the total time to produce one course video hour is 351-557 hours. Another study by Clark (2010) has noted that one program might take as little as one hour or up to 500 hours, depending on the person's design skills and knowledge of the subject, the amount of material to be converted, and the type of transformation needed.

Using these notional costs, this paper considers two examples of costs related to customizing and revising courses using OER. These examples are described below.

4.2.1 Cost effectiveness of customizing a course using OER

There has been some demonstrative evidence of cost effectiveness in course development because of digitization of content, particularly through using OER. Using openly-licensed resources, developers can access existing content and contextualize it to their own curriculum, speeding up the process of materials development. Designers and developers need to consider curriculum design, materials development, quality assurance, platform customization, and evaluation when developing a course. Following this process step by step is often protracted and costly. However, there is evidence of a professional development initiative demonstrating that burdens in both design and development phases can be shared, shortening the time required to design courses and develop the accompanying resources. This approach is more cost-efficient than typical course development initiatives.

The UNESCO ICT Competency for Teachers (ICT-CFT) focuses on establishing the guiding principles for the use of ICT in teaching and sets out the ways in which ICT can transform education. The Framework puts emphasis on the skills teachers need to make ICT an integral part of how they practise their profession, and aims to offer support in drawing up national standards and policies in this area (Agence Française de Développement, 2015).

The ICT-CFT identifies 18 ICT competencies to which teachers should aspire, subdividing these into 64 objectives. The competencies range from encouraging teachers to understand national priorities as identified in national ICT in Education policies, to learning how ICT can support the curriculum, assessment strategies, pedagogy, school and class organization, administration, and ongoing professional development. The framework has three approaches of increasing sophistication: Technology Literacy, Knowledge Deepening, and Knowledge Creation. By selecting and adapting competencies as framed by an international framework and developed by educational experts, the design phase is shortened.

In Africa, seven countries have participated in enhancing the ICT-CFT competencies. In 2014, Kenya was involved in the project, and it took approximately three years to develop 90 notional hours of training. The Kenyan ICT-CFT Course was developed from existing OER but also includes new materials produced by Kenyan developers to respond to the Kenyan context. The Kenyan development team also added value to work done previously by mounting the course on a Learning Management system and adding online activities[2].

From 2015 to 2016, the Rwanda Education Board selected a set of ICT-CFT competencies and noticed an overlap with some of the Kenyan materials. They customized the Kenyan materials and developed additional content for the 60-notional-hour ICT Essentials for Teachers Course, aimed at in-service teachers[3]. The development time was under two years.

Between 2015 and 2016, the University of Djibouti also adapted parts of the Kenyan ICT-CFT course materials. While the curriculum was similar, the University translated the materials into French and contextualized the units of study to respond to the needs of academics and lecturers working there. In 2016, the Djibouti materials in French were adapted by the University of Lomé in Togo, to support pre-service teacher education in its faculty of education. The repurposing and the development of the Togo version was achieved in less than a year.

In 2017, the Zimbabwe Ministry of Primary and Secondary Education customized the Rwandan materials to create an offline version distributed using USB sticks because of restrictive bandwidth. The Zimbabwe model required all the OER downloaded and customized to work offline. A series of master trainers facilitated the courses face-to-face. The Zimbabwe ICT Essentials Course is 60 notional hours and was developed from curriculum design to course pilot in only five months.

In 2017, the Matthew Goniwe School of Leadership and Governance in South Africa developed an in-service teacher professional development course called MG Online, which drew materials from all the above. It added value by writing additional units particularly for the Knowledge Creation level of the UNESCO framework. This course is 80 notional hours of study and was developed and piloted over seven months[4].

Late in 2017, the Mozambique Institute of Open and Distance Education began customizing units of study drawn from all the above resources, as UNESCO had developed a repository of OER linked to the ICT-CFT competencies. These units are currently being translated into Portuguese and contextualized for Mozambique in-service teachers.

Thus, since 2011, the pool of openly-licensed resources linked to each of the ICT-CFT competencies has grown. These OER were developed as new countries adapted existing OER or developed additional materials. The open licence on these resources permitted adaptation and encouraged new developers to fashion courseware that responded to local needs. The customization of existing OER, rather than

[2] *See http://kictcft.or.ke/*
[3] *See http://ict-essentials-for-teachers.moodlecloud.com/*
[4] *See http://mgonline.mgslg.co.za/*

developing and in many instances duplicating materials meant that the development phase was shortened. As OER are free, production costs too were slashed.

However, it was not possible to determine the actual costs of course production for all the countries, as attempts to calculate costs were made after the initiatives were completed. Additionally, the process involved in each country differed, and each country adopted a different model suitable to its context. In most instances, consultants provided training on how to develop course materials and different stakeholders within the countries developed and adapted materials, again with consulting support in editing and quality assurance of material. In Mozambique, for example, consultants facilitated a course development workshop including the identification of appropriate OER. Another local consultant was tasked with adapting the materials, including translation of the materials into Portuguese. For Zimbabwe, course production costs were estimated, as the model was different, with consultants tasked with adapting the course materials. The overall cost of the development team is shown in Table 2. The costs were for developing a professional development in-service teachers course of 14 units of study, or 60 notional learning hours. The total time taken to create one notional hour of learning was two hours at a cost of $64 per hour.

Development team	Time (days)	Costs (US$)
Project coordinator	2	1,090
Course developer	13	2,730
TOTAL	**15**	**3,820**

Table 2. *Time taken to develop one hour of training*

In Defelice's model (2018), the UNESCO ICT-CFT can be regarded as Level Two (Limited e-learning/level of Interaction). That model estimated 71 hours of development time compared to two in the UNESCO ICT model in Zimbabwe. Those two hours per unit were spent mainly on technical tasks. The materials were converted from a version accessed online to digital resources that could be stored in a flash drive, with only a small amount of time used to contextualize the materials, and requiring only minor adjustments to align with the new context. The authors recognized that the comparison is simplistic, as there are likely variations in functionality, features, and expected user experience.

Nevertheless, participants in the UNESCO ICT-CFT project observed that adaptation of materials is getting quicker over time, resulting in savings. This is enhanced by the consultants' familiarity with the materials and process, which increases over time. As all this content is being shared under an open licence, the potential for achieving economies of scale grows further as and where it is used by other institutions. However, this model also assumes that investing in content creation is sufficient to produce high quality content, as the content generated is only as good as the content developers' knowledge and skills levels.

The example in the next section provides some evidence of how costs can be reduced over time when adopting OER.

4.2.2 Cost-effectiveness of remixing and revising an OER course

The South African Institute for Distance Education (SAIDE), remixing an online course – Facilitating Online Learning Course - provides another example of OER.

The course was derived from two existing courses: SAIDE's Supporting Online Learners, and the Centre for Education Technology (CET) at the University of Cape Town (UCT) online course Facilitating Online. SAIDE worked on designing, developing and implementing a remixed OER course that would provide essential elements of each of the original resources and run online over three weeks (Mallinson & Krull, 2015). The plan was to aim for an appropriate balance of the elements, and to shorten and tailor the remixed course without losing the intrinsic value of either original resource. It was believed these two integral changes would provide a course with a unique flavor and prove an attractive offering to enhance the professional development of academic faculty in African higher education institutions.

The work involved include changing the platforms from Sakai to Moodle, and then from Moodle to Blackboard; redesigning the remixed course for the new purpose drawing on tried and tested learning pathways, resources, and activities; and revising the overall structure of the course. Subsequent revisions were made based on participant feedback and client requirements. These ranged from making minor revisions to the structure, activities, and resources; and major changes around the duration and length of the course.

The developers traced the time and effort required to revise and adapt the various versions of the course. Table 3 outlines the time taken, and actual costs for remixing or revising the course.

COURSE	Notional learning hours	Time (days)	Cost	Cost per notional learning hour
FOLC 1 remix (2014)	20	3.9	$1113.59	$56
FOLC 2 revise (2015)	26	1.75	$976.62	$38
FOLC 3 revise (2017)	26	1.5	$259.40	$10
FOLC 4 revise (2017/8)	26	5.7	$3369.20	$130

Table 3. *Time for remixing and revising an OER course*

Table 3 data indicate the costs of revising the course reduced in the second and third version. However, costs increased in the fourth revision due both to major adaptations being made to the course, and to porting the course from Moodle to Blackboard. The developers also reported that they found it takes less time for minor revisions of the course that do not require porting to an incompatible learning management system (LMS) or virtual learning environment (VLE).

Within Defelice's model (2018), the FOLC course can be regarded as Level Two (Limited e-learning/ level of Interaction). That model estimated 71 hours of development time compared to a range of 12-46 hours in the FOLC course. The developers note that minimal graphics and rich media were used. Table 4 shows the costs of facilitating the course.

Data from Table 4 show that facilitation costs varied between the different versions of the course. The developers note that the course facilitation takes more time than the remix/adapt task. The remix and adaptations were all performed by experienced learning technologies practitioners, which assisted in expediting the task. However, the facilitators' and co-facilitators' expertise, prior facilitation experience, and time and effort on task, varied considerably. Other variables can impact on facilitation costs, including participants' level of familiarity with ICT, and the learning style of participants.

This example provides evidence of increased cost-efficiency in course remixing and revision using OER. It also highlights the variables that impact on costs such as the experience of staff and production tools used. Further cost modelling of similar kinds might be valuable in helping determine the relative cost-effectiveness of digital learning investments on a smaller scale.

COURSE	No. of facilitators / co-facilitators	No. of participants	Time for facilitation (days)	Cost of facilitation	Cost of online facilitation per day
FOLC 1 remix (2014)	3	19	18.6	$ 5310.96	$ 286
FOLC 2 revise (2015)	3	8	8	$ 6138.74	$ 767
FOLC 3 revise (2017)	3	22	10.75	$ 4020.69	$ 374
FOLC 4 revise (2017/8)	2	12	8	$ 5288.347	$ 661

Table 4. *Time for facilitating an OER online course*

5

CONCLUSION

Cost-effectiveness analyses require access to detailed cost data. However, there is little published data on the costs of ICT in education in Africa that provide specific cost data to undertake a good cost-effectiveness analysis. Measuring the cost-effectiveness of digital learning is complex and depends on several factors, such as the aspects of digital learning measured, the political contexts of digital learning initiatives, the scale of the initiative, and the varied effects of the investment. Despite many evaluations of digital learning initiatives in Africa, there remains a lack of reliable data available to provide clues about the potential for digital learning initiatives to be cost-effective. Evidence also suggests that measuring cost-effectiveness, and the costs and benefits, of digital learning to make well-informed decisions about educational options is complex and problematic. Despite a widespread belief that investing in ICT is cost-effective, as well as ongoing reductions in the price of hardware, software and connectivity, the total cost of ownership of ICT – which includes maintenance, upgrading, skills, and development – remains high (Adam et al., 2012). Based on available data, it is difficult to say whether digital learning is cost-effective.

Nevertheless, some key lessons can be drawn. First, conducting research on the cost-effectiveness of digital learning on a large scale requires the political space to be able to cost interventions accurately, which can often be difficult given the highly politicized nature of public education systems. Second, where proper costing can be done, cost-effectiveness research also depends on reliable models for assessing the likely educational and economic gains of changes in the output of education systems, given this is a core rationale for the initial investment. Third, there are some proven cost-benefits of digital learning on a small scale, as illustrated by the example of adopting an OER model to develop and adapt/remix existing courses. Fourth, cost-effectiveness analyses require detailed underlying cost and impact data. Given that information on DL costs is scarce and prone to becoming outdated, program implementers and donors of ICT in education initiatives can consider adding costing data and an assessment of program cost efficiency in their monitoring and evaluation design. Fifth, it will be useful to develop some suggested formats for costing program data to allow for comparisons between programs, and more rigorous cost-effective analyses to be conducted.

Much work need to be done related to the costs of ICT in education investments. It is important to improve understanding of the costs and benefits associated with ICT types and uses in different educational contexts, so that resources can be targeted effectively. Given the lack of available cost data, it is necessary for African countries to invest in producing high-quality evaluations to determine the effects and costs of interventions. At least on a large scale, this is likely only possible with the leadership and support of political decision-makers across education systems.

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