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# Costs of information and communication technology in developing country school systems: The experience of Botswana, Namibia and Seychelles

**Andrew Paterson**
**Human Sciences Research Council, South Africa**

## ABSTRACT

Despite the steady decline in the relative cost of acquiring information and communication technology (ICT), the cost of owning and maintaining sustainable computer systems in schools is rising. Simultaneously, Ministries of Education (MoE) in sub-Saharan Africa are under pressure to invest in ICT. However, there is very little evidence upon which decision makers can base their decisions to allocate finances to ICT. This article is based on a survey of total costs of owning computer rooms in 62 schools across Botswana, Namibia and the Seychelles. It reveals that in Botswana and Seychelles, where government provided computer facilities to all post-primary schools, ICT expenditure per school is much higher than in Namibia where school computer facilities are funded from several sources including government, NGO and the community. It is argued that high expenditure is not necessarily associated with efficiency of resource usage, and that internationally benchmarked research is needed in order to support optimal MoE and school level decision making.

***Keywords:*** *Cost, total cost of ownership (TCO), information and communication technology (ICT), financing, schools, developing country, Africa*

## INTRODUCTION

Among the technologies strongly associated with education, paper and book printing significantly pre-date the advent of mass education systems in Europe (1780-1870), while chalkboards (circa1800) and modern graphite pencils (circa 1795) are technologies that have long been applied in education settings. In contrast, information and communication technologies (ICTs) are historically recent additions to the basket of discretionary (non-teacher salary) expenditure options that are available to those tasked with apportioning the education budget. The potential for ICT to be applied in schools has radically increased from the mid 1990s. This is on account of the combination of massive improvements in computer processor power, information storage capacity and software utility; rising ubiquity of telecommunications services; the explosion of the Internet; and steadily declining relative costs of acquiring hardware, software and telecommunications services.

In many, though not all, developed countries, these technological and cost advantages have accounted for mass access and use of computers in education.[1] The same is not evident in developing countries, largely because the cost barriers to supplying ICT hardware, software and connectivity in these education environments are significant. In developed countries there is a growing realisation of what in 1996 Oberlin called the 'financial mythology of information technology' which he described as follows: 'While the per unit price of information technology is declining rapidly … the total cost of owning and maintaining systems is steadily rising …the falling prices mislead many to expect cost savings that will never materialise' (Oberlin, 1996:21). This was largely because of consistent underestimation of the management, technical support, curriculum development and training expenditure that is essential to ensure sustainable ICT access and use in education. Given global enthusiasm for applying ICT in schools, higher

education institutions and in national education systems, it is essential to put in place appropriate costing, financing and planning processes to aid budget allocation decisions.

In developing countries that have to deal with constrained budgets, financial allocations to ICT must properly take into account the full costs of sustainable ICT systems as well as address the challenge of providing ICT on an equitable basis. Education planners must investigate costs related to ICT so that key strategic questions around effectiveness, efficiency and sustainability can be better understood. Such an understanding is particularly important, given that sometimes wildly extravagant claims are made for ICT and its impact on education processes.

This article seeks to address the matter of ICT financing by examining the financing patterns of ICT in schools of three SADC countries. The aims are to present and discuss the full costs of running computer rooms in these countries, and then to compare cost profiles with reference to the different conditions in each country that influence spending patterns.

This article develops findings drawn from 'An analysis of ICT costs in three SADC countries: Botswana, Namibia and Seychelles' (Paterson, 2004) which forms part of a larger project, commissioned by the Southern African Development Community (SADC), that focused on the conditions necessary for effective implementation of ICTs in Botswana, Namibia and Seychelles (Chisholm, Dhunpath & Paterson, 2004).

This article first provides a brief literature review, followed by an account of the methodology and sampling approach. Second, the cost calculation model standardised across each country is explained. The third section constitutes an analysis of the ICT cost data. Finally, the relevance of the analysis to ICT financing challenges is sub-Saharan Africa is considered.

## LITERATURE ON FINANCING ICT IN DEVELOPING COUNTRY SCHOOLS

There is limited information on how schools in developing countries finance their ICT resources. Available work refers to Belize (Rock, Glick and Sprout, 1991), to Belize, Chile, Costa Rica, Jamaica and Mexico (Potashnik and Adkins, 1996), to extrapolations for LDCs based on data from Israel (Osin, 1998), to Costa Rica (Wolff, 1999), to Barbados, Turkey, Chile and Egypt (Bakia, 2000), to Zimbabwe and South Africa (Cawthera, 2001) and to the Phillipines (Roderigo, 2005). Ottwanger, (2003:37) collected country level ICT costs for six nations in sub-Saharan Africa but the data was not obtained in a way that enabled systematic and comparative analysis. Within this small collection, work on the SADC region is limited to only two countries. [2]

The literature on developing countries tends to focus on costing the technological elements of hardware, software and telecoms to the relative neglect of a range of cost elements such as training, technical support, curriculum development and planning. In this article, 'total cost of ownership' (TCO) a methodology that derives from management of computers in business environments, is used as a framework to identify costs. TCO draws attention to the importance of obtaining an appropriate combination of purchases, inputs and activities in order to operate a sustainable ICT environment. This implies that failing to fund key elements may fatally undermine the success of the whole ICT financing programme (McKenzie, 2003: 1). In this way costs must be related to financing within a time-based budget allocation framework that in turn is informed by policy. There is evidence of schools and school districts in a number of developed countries applying TCO methods in financial planning and management of ICT facilities. [3] In this article the concept of TCO is applied in three developing countries, in order to better understand the financial challenges facing developing country school communities and MoEs that aim to finance ICT on any scale. Using a TCO approach and method can contribute to understanding and achieving an appropriate balance between the strategic inputs required to sustain ICT facilities in

individual schools or in groups or systems of schools. If applied to a national sample the process can reveal differences between countries in expenditure patterns, which can be explained with reference to policy and conditions in schools.

## METHODOLOGY

Botswana, Namibia and the Seychelles elected to be the countries in which this research was conducted. In-country researchers from each MoE were involved in the project to facilitate interaction with role players in each country. Meetings were held with SADC Permanent Secretaries to ensure that there was a shared understanding of the aims, objectives and methodology and to ensure that countries took ownership of the research project. The draft results were presented to SADC Permanent Secretaries at a regional conference in August 2003.

Data was obtained by means of a survey of schools in each country. The aim was to audit ICT equipment in each school and to capture all the fixed and recurrent costs of ICT provisioning (such as telecommunications costs) and services (e.g. computer repairs and network maintenance) as well as other human resource costs such as training. The instrument was based on key cost categories that were identified from the TCO literature. These main categories/themes were developed in a workshop attended by the in-country researchers. The instrument, after piloting, included 117 questions covering the cost categories given above.

In-country researchers delivered and collected the instruments and followed up on queries from respondents. The returns were captured, spot checked for accuracy and cleaned. The data was loaded into and queried in SPSS. The analysis refers only to computers used for classroom teaching and learning.

## CALCULATION OF COSTS

As indicated, the aim of this study was to consider the 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.[4] The cost model was built using the average in-country cost for each item. There was some missing data from the returns because certain costs associated with the implementation of ICT in schools were not incurred at the school level but rather at the level of the MoE. For example, Botswana and Seychelles MoEs budgeted for and provided technical support to schools and as a consequence schools did not know the cost of these services. This information was obtained through further interaction with the Ministries concerned. Some values, such as recorded expenditure amounts, required confirmation or explanation where they appeared to be disproportionately large or small by comparison to the mean distribution of values. They were checked with in-country researchers to ensure the highest possible levels of accuracy.

Expenditure on certain high value items (computer room, hardware and peripherals, software and training contracts with external providers), was annualised over the estimated life of the item in question so that an annual cost could be derived. On this basis it was possible to populate Table 2 (discussed below) so as to compare costs across the three countries.

## SAMPLING STRATEGY

On account of time and budget constraints, only schools that had a computer room and used computers for teaching and learning were sampled, except in the case of the Seychelles, where that country's small population of Secondary Schools – all with computer rooms – was surveyed. Fieldworkers aimed to achieve a balance between primary and secondary, rural and urban, and public and private schools proportionate to the occurrence of these school types (with computers) in each national school system. Private or NGO-established computer centres or tele-centres operating independent of schools were not surveyed.

In Namibia, a reasonable spread of urban and rural schools was obtained, whereas in the case of Botswana, the sample was restricted to a radius of 50km from the capital city, Gaborone. Assuming that ICT costs will tend to increase with distance from an urban centre, the Botswana cost data is likely to slightly underestimate school ICT costs in that country.

## THE SAMPLE AND THE NATIONAL POPULATIONS OF SCHOOLS WITH ICT

In all, a total sample of 62 schools was obtained (Table 1). The low number of primary schools included from Botswana and Seychelles in the sample is simply reflective of the low numbers of primary level schools with a computer room in those countries. When the fieldwork was undertaken in 2003, Botswana and Seychelles had already supplied a computer room to every school offering post-primary education. The few primary schools in Botswana and Seychelles that do have computer rooms own these facilities because they were specifically established for pilot purposes, or they owe their existence to school community initiatives.

***Table 1:*** *Sample of Schools*

| | **Country** | | | |
|---|---|---|---|---|
| **School phase** | **Botswana** | **Namibia** | **Seychelles** | **Total** |
| Primary | 1 | 9 | 1 | 11 |
| Middle/Junior Secondary | 19 | 2 | - | 21 |
| Senior Secondary | 9 | 9 | 121 | 30 |
| Total | 29 | 20 | 13 | 62 |
| | | | | |

*1. The 12 schools surveyed in this category represent the entire population of public secondary schools (10) and private secondary schools (2) in the Seychelles*

In Botswana and Seychelles, the distribution of computer rooms is driven by a policy that follows a phased approach to implementation, starting with secondary schools, and this is reflected in the sample. In Namibia, there is a more or less even balance in the distribution of computer rooms between Primary and Secondary schools that is the outcome of an 'organic' growth in the number of schools with computer facilities. This is partly because the Namibian government, though supportive of ICT in schools, had not yet made the strategic decision that all schools in a particular phase or grade range should provide learners with access to ICT. Under these circumstances school-based and NGO-based initiatives to set up, facilitate and operate computer facilities in schools in that country are important. Circumstantial evidence suggests that there is significantly greater NGO activity in the field of ICT education in Namibia than in Botswana and Seychelles. The existence of ICT education-based NGOs across the school spectrum in Namibia largely explains why the number of primary and secondary schools in the sample for that country is almost equal in number – there being no policy directing ICT provision in any particular phase.

In that country, NGOs and school communities acquire ICT for schools in terms of their own programmes and objectives and the cumulative impact does not appear to favour primary or secondary schools.

Reliance on NGO initiatives appears to be a fairly typical situation across a number of sub-Saharan African countries where, according to Ottwanger (2003: 29) the 'most successful in the implementation of ICT in practice are a few, often donor-funded projects'. A concomitant characteristic across many countries is that, even where they have developed ICT curricula and materials and provided teacher training in some way, 'most of the countries lack national umbrella organisations watching over a co-ordinated implementation' (Ottwanger, 2003: 29-30).

In the sample the numbers of schools in each phase (Primary, Junior Secondary and Senior Secondary) were not consistent across each country. There were very low numbers of accessible primary schools with computer rooms in Botswana and Seychelles, where the policy emphasis was on equipping junior and senior secondary schools. Only 11 (<20%) of the sample of 62 were primary schools. It was therefore decided not to separately analyse ICT costs for each school phase. The main focus of the analysis was therefore on costs per school in each country rather than on differences in costs per school phase.

## DISCUSSION

Firstly, the overall pattern of ICT expenditure is described and related to MoE policy on ICT access in the three countries. Then the allocation of funds within each country's expenditure envelope is discussed to show differing allocations of value to elements of the ICT package found between the school systems. This is followed by discussion of the main findings.

### ICT Costs

Table 2 provides a summary of ICT costs based on the TCO approach. The Botswana and Seychelles MoEs set out to systematically provide access and support ICT in their secondary schools and were primary funders of human resource, training and technical support costs. Unfortunately, expenditure data in these categories was not available from the Botswana MoE.

***Table 2:*** *Annual Total Costs of Ownership in US$ per school in Botswana, Namibia and Seychelles, 2003*

| | Category | Second level description | Botswana | Namibia | Seychelles |
|---|---|---|---|---|---|
| 1 | Building* | Build from scratch | 7 241 | 3 342 | 5 790 |
| | | | | | |
| 2 | Hardware and peripherals** | Workstations, peripherals, network and internet facilities | 11 384 | 7 602 | 15 742 |
| | | | | | |
| 3 | Software*** | Systems software and applications | 443 | 275 | 761 |
| | | | | | |
| 4 | Curriculum and subject-specific software**** | Subject specific software | 1 570 | 2 473 | 1 522 |
| | | | | | |
| 5 | Recurrent | Software licensing and upgrading | 171 | 208 | 570 |
| | | Maintenance | 1 041 | 1 116 | 4 000 |
| | | Insurance | 1 979 | 834 | 0 |
| | | | | | |
| 6 | Internet connectivity (recurrent) | Leased Line rental/ ISDN line rental | 100 | 170 | 192 |
| | | Internet Service Provider fees | 864 | 936 | 996 |
| | | Call charges | 2 484 | 1 416 | 648 |
| | | | | | |
| 7 | Consumables | | 3 719 | 573 | 963 |
| | | | | | |
| | School level technology costs | | 31176 | 18945 | 31184 |
| | | | | | |
| 8 | Human resources for technology management | Computer technician, user support, and computer room manager | n.d. | 2184 | 12115 |
| | | | | | |
| 9 | Personnel training and professional development***** | Technical support training, computer room manager | n.d. | 314 | 238 |
| | | | | | |
| 10 | MoE management and administration | Planning and administration costs | n.d. | 754 | 2473 |
| | | | | | |
| | Support costs | | n.d. | 3252 | 14826 |
| | | | | | |
| | Total cost of ownership (TCO) | | | 22197 | 46010 |
| | | | | | |

* *Annualised over 20 years*
** *Annualised over 4 years*
*** *Annualised over 4 years*
**** *Annualised over 4 years*
***** *Annualised over 3 years*

### School Level Technology Costs

The distribution of school level technology costs (Table 3) by category, calculated as a percentage, reveals a broadly similar pattern between countries, where in each case, hardware, software and peripherals constituted the single biggest expenditure followed by recurrent expenditure, the computer room and lastly consumables. Within this pattern, the higher levels of expenditure on hardware software and peripherals in the Seychelles were on account of higher costs of supply and installation on the relatively isolated island archipelago. The lower costs of the computer rooms in Namibia were attributable to lower labour-construction costs. The high share of costs allocated to consumables in Botswana (printer cartridges, paper and stiffy disks) was based on supply of these items to schools at the beginning of the computer room building and equipment programme, which may have been adjusted over time. The 'retro-fitting' of electricity and other installations to existing classrooms, which is less costly than special rooms purpose-built for computers, was quite common in Namibia.

***Table 3:*** *Comparison of school level technology costs in percent**

| | | **Botswana** | **Namibia** | **Seychelles** |
|---|---|---|---|---|
| 1 | Computer room | 23.2 | 17.6 | 18.6 |
| 2,3,4 | Hardware software peripherals | 43.2 | 54.6 | 57.8 |
| 5,6 | Recurrent (incl. connectivity) | 21.3 | 24.7 | 20.5 |
| 7 | Consumables | 11.9 | 3.0 | 3.1 |
| | | 99.6 | 99.9 | 100 |

** Percentages may not add up to 100 on account of rounding*

### Influences on Total Costs of Ownership

Total annual total cost of ownership (TCO) per school can only be analysed for Namibia and Seychelles because this data was not available for Botswana (Table 2). It is striking that in US$ terms, expenditure on ICT in Namibia was less than half that of the Seychelles. Moreover, Seychelles expenditure on computers was higher for both (a) school level technology costs and (b) support costs which were supplied centrally from the MoE. This indicates the extent to which the Seychelles MoE has committed itself to ICT as an important element in its national curriculum strategy.

In contrast, the greater overall share of costs is borne at the school level in Namibia, which suggests that in that country government depends on school communities and NGOs to sustain computer activity at schools. The shape of expenditure in Namibia is consistent with a country that is in the process of developing policy but where the MoE does not yet have the budget to underwrite the expansion of computers into schools on a large scale. The Namibia education system consists of a highly dispersed population of 1545 schools, while the Seychelles MoE is responsible for 50 schools with a more dense population, so putting in place computer rooms in the latter country will be a more financially-onerous undertaking. The first step on this path will be for the MoE in Namibia to formulate and implement policy regarding national aims for computer rooms in schools, including norms and standards for such learning environments, and where such a roll-out should start. Until this happens, the distribution of schools with computer rooms in Namibia will be driven by local initiative and will reveal a variety of approaches to the challenge of providing ICT access to learners.

It is important to observe that in the case of both Botswana and the Seychelles, where investment in computer infrastructure in schools was driven by government, the average expenditure per school was almost double the expenditure in Namibia, where support for such expenditure came from NGOs and the community (Table 3). A key question is whether a model of ICT provision in which MoE and NGOs share funding and roll-out – as appears to be the case in Namibia – could provide more efficient access to computer rooms of equivalent quality than facilities in countries that are (almost) entirely driven by government funds.

This question becomes more complex when we compare the proportionate allocation of funds to all cost categories within a TCO framework (See Table 5). The most important difference between the two countries is that the proportional allocation of expenses in categories 8-10, all of which refer to human resources and planning, were much higher in the Seychelles – with a combined percentage of 33.25% – than in Namibia, with a combined percentage of 14.2%. Support costs were mostly absorbed by the individual schools in the case of Namibia and funded by the MoE in Seychelles.

***Table 5:*** *Comparison of Total Costs of Ownership (TCO) in percentages: Namibia and Seychelles**

| | | **Namibia** | **Seychelles** |
|---|---|---|---|
| 1 | Computer room | 15.1 | 12.6 |
| 2,3,4 | Hardware software peripherals | 46.6 | 39.2 |
| 5,6 | Recurrent (incl. connectivity) | 21.1 | 13.9 |
| 7 | Consumables | 2.6 | 2.1 |
| 8 | Human resources for technology management | 9.8 | 26.3 |
| 9 | Personnel training and professional development | 1.4 | 0.5 |
| 10 | MoE management and administration | 3.4 | 5.4 |
| | | 100 | 100 |

** Computer costs are affected by the standards for provision set by a MoE (such as performance benchmarks set for computers, number of computers per computer room, etc.)*

Could it be that the Seychelles approach – though more expensive – is more sustainable, given their emphasis on human resources costs to support the operations of the computer room?

These questions are raised deliberately because the cost data collected, though describing what current costs are, cannot assist in establishing which allocation patterns are more efficient or produces better quality of service than others. For example, the 9.8% allocation to school-based technology management in Namibia may seem to be cost efficient in comparison to the Seychelles value of 26.3%. But a lower allocation to technology management may buy less qualified user support, or user support that is not available on call, leading to extended down-time of the school computer network. This wasted time erodes the value of all investment inputs into the installation. More research needs to be done on hidden costs and opportunity costs of ICT investment in order to make the TCO model more sophisticated so that the impact of different expenditure patterns on efficiency and quality of ICT access can be understood.

**Cost Indicators and International Comparisons**

A simple and useful cost indicator is derived by calculating the cost of computers per learner or per computer. In Seychelles schools, the expenditure on computers was three times that of

Namibian expenditure per learner and four times that of Namibian expenditure per computer (Table 6).

| ***Table 6:*** *Cost indicators for Botswana, Namibia and Seychelles in US$, 2003* | | | | |
|---|---|---|---|---|
| **Category** | | **Botswana** | **Namibia** | **Seychelles** |
| School level technology costs | | 31 176 | 18 945 | 31 184 |
| | | | | |
| Support costs | | n.d. | 3 252 | 14 826 |
| | | | | |
| Total Cost of Ownership (TCO) per school | | n.d. | 22 197 | 46 010 |
| | | | | |
| Annual cost per learner | Average n of learners per school | 873 | 842 | 594 |
| | | n.d. | 26.36 | 77.46 |
| | | | | |
| Annual cost per computer | Average n of computers per school | 29 | 27 | 13 |
| | | n.d. | 822 | 3 539 |

## FURTHER DEVELOPMENT OF COSTING MODELS FOR AFRICAN COUNTRIES

The cost analysis applied in this study was deliberately restricted to a simple set of parameters that afforded relatively easy data access and which could be replicated. Consequently, there were relevant cost elements and influences on costs that were not incorporated, but which deserve noting in the interest of developing a more nuanced cost analysis.

In the first instance there is the matter of whether to use refurbished (or reconditioned) computers rather than new computers. There are conflicting views on whether refurbished PCs are a more viable technology option than buying new computers in terms of cost-effectiveness (See: Open Research, 2004; InfoDev, 2005: 3). For example, one argument is that opting for refurbished computers may reduce costs of acquisition of the hardware, but that the overall costs of maintaining older machines will outweigh the initial cost saving. A decision on this matter could appreciably affect ICT costs over a lengthy period of time.

Second, there is the option of 'cost recovery' in respect of ICT fees that could be levied at school level, in order to subvent MoE expenditure. But there are also equity, administrative, legal-regulatory and cultural aspects that must be satisfactorily addressed (InfoDev, 2005: 3).

Third, the dominant language of software and of the Internet is English. In linguistically diverse African countries, MoEs will come under pressure to support the development of content, materials and software that can add considerably to government's financial burden (See: Gyamfi, 2005; Dalvit et al., 2005).

Fourth, costs of hardware and software are dictated largely by technology cycles where each generation becomes progressively cheaper to purchase as it is superseded by new models/versions with higher performance. The MoE can control expenditure through defining the

economic life-cycle – or the useful financial life – of an item, and also through timing of its purchases to maximise the efficiency of its systems.

All of the above aspects have the potential to impact significantly on ICT costs, but are difficult to introduce into a model that must be used for comparative purposes.

## CONCLUSION

This article observes that in developing countries that have to deal with constrained budgets, financial allocations to ICT must properly take into account the full costs of sustainable ICT systems. However, there is a dearth of information about ICT costs that can assist MoE decision makers to apportion their budgets between competing demands between the four 'T's' - teachers, textbooks, time and technology.

This is because a body of work that upholds systematic study of ICT costs in African schools has not yet emerged. The task of generating a coherent understanding of ICT costs through research is complex because investment in ICT in African schools is mainly dispersed in resource centres or in small networks of pilot schools (Ottwanger, 2003:29) which operate under different conditions with widely varying technology configurations. A shared approach to collecting data on ICT costs is essential to raise the comparability of research studies.

The analysis of cost data suggests that very few countries in sub-Saharan Africa will be able to contemplate the aggressive implementation of computer rooms in all high schools, as was achieved in Botswana and the Seychelles. Most will find themselves in a situation analogous to Namibia's. In that country, government depends on school communities and NGOs to sustain computer activity at schools. A key question is whether such a model of ICT provision in which MoE, NGOs and communities share the financial burden can be as sustainable, equitable and provide equivalent quality of access as facilities in other countries that are (almost) entirely driven by government funds.

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## ENDNOTES

[1] The potential benefits of using of ICTs in educational administration at the school level (School Management Systems) and at the systemic level (Education Management Information Systems) are noted but not addressed in this paper.

[2] There is a body of publications that deal specifically with the financing of distance education – in higher education and adult education – that will not be addressed here (eg: Butcher, 2003).

[3] The following are examples of TCO-based tools giving the sponsoring organisation acronym and URL: IAET at AEL <http://129.71.174.252/tcov2/bkgnd.cfm> (Date accessed: 31 January 2006); BECTA at <http://schools.becta.org.uk/index.php?section=pr&catcode=ss_to_pr_su_03&rid=9650> (Date accessed: 31 January 2006); ISTE at <http://tsi.iste.org> (Date accessed: 31 January 2006); CoSN & Gartner at <http://classroomtco.cosn.org/gartner_intro.html> (Date accessed: 16 September 2003).

[4] A detailed account of how these values were calculated is available in Paterson (2004).

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