Computers in secondary schools

in developing countries:

costs and other issues.

(Including original data from South Africa and Zimbabwe)

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Glossary of acronyms and technical terms

CAI	Computer Aid International
CD ROM	Compact Disc Read only Memory
CPU	Central Processing Unit
DSL	Digital Subscriber Line
DOS	Disc Operating System
EFA	Education For All
GB	Giga Bite
GST	Government Sales Tax
ICT	Information and Communication Technology
ISDN	Integrated Servers Dial-up Network
ISP	Internet service provider
LAN	Local Area Network
LDCs	Less Developed Countries
MG	Mega Bite
MHz	Mega Hertz
MS	Microsoft
NGO	Non-Government Organisation
NQT	Newly Qualified Teacher
PCs	Personal Computers
R	Rand
RAM	Random Access Memory
RSA	Republic of South Africa
SVDU	Super Visual Display Unit
UK	United Kingdom
USA	Universal Services Agency
US$	United States Dollar
VSAT	Very Small Aperture Networks
WAN	Wide Area Network
WorLD	World Links for Development
WUSC	World University Service of Canada
Z$	Zimbabwe Dollar

Executive Summary

This research is mainly concerned with the costs of computers in schools in developing countries. It starts with a brief overview of the information revolution and its consequences. It then briefly examines some of the arguments for the use of computers in schools in developing countries, before reviewing previous work undertaken on the costs of such provision. An analysis of this literature indicates that the costs of equipment (hardware and software) may account for only 16-20% of the total cost of computer provision (excluding salaries) over five years.

The cost data gathered at school / telecentre level, as a part of this research, is then analysed. A framework which yields data on: housing, equipment, training, running and external support costs was developed and used to gather this data. The data is categorised into Basic, Basic plus and Deluxe provision. Basic and Basic plus provision use second-hand / refurbished equipment, with Basic plus provision also providing training and support. Only Deluxe provision purchases new equipment. In addition to this a rural school, community based telecentre provision and commercial provision are looked at. The data supplied is analysed with various figures being produced for the different categories including:

- *"Annual cost per regular student user",* varying between about US$10.00 and US$644 with a figure of between $20 and $30 appearing to be fairly common and attainable. The variation occurs mainly due to the level of usage, provision of training to teachers and the number of students per computer.
- *"Cost per computer over 5 years",* varying between about $1,000 and $10,000 depending on whether new or second-hand equipment is purchased, the amount of training and support provided and the amount of and cost of connectivity to the web.
- *"Actual regular users as a % of possible regular users"*, varying between 3% and 111%, with 20% - 30% being common.

The paper then proceeds to raise other issues which can affect computer provision and utilisation including the processes of allocating provision, training of teachers in the use of ICT and models of provision.

Conclusions are then drawn and recommendations made which can be summarised as follows:

- The usage of existing computing facilities is often only a fraction (average around 20-30%?) of what it could be.
- Probably the best way to both reduce unit costs and increase provision is to extend usage. Research is needed into actual computer usage in schools, the barriers preventing increased usage and how these might be overcome.
- For planning effective computer provision it should be realised that the costs of equipment tend only to be a fraction of the total cost of provision over 5 years. This research indicates that the total cost of ensuring effective computer learning in schools over a five year period (excluding teacher salary costs) could well be around five times the cost of procuring computer equipment.
- The training of teachers in the use of ICT in schools is an important aspect of provision which may often be overlooked and under-budgeted. Low-cost, easy-to-use training packages need to be developed as a part of the solution to this problem.
- Policy makers need to be aware of the range of computer provision available. Expensive, state of the art equipment is not essential to achieving good educational outcomes.
- Careful consideration should be given to the processes involved in the provision of computers in schools so as to ensure high levels of usage (see section 6).
- Where there is sufficient usage, computer labs should have a minimum of 20 computers. This will reduce unit costs by spreading the high fixed costs of training over a larger number of users.
- Benchmarks and ratios for usage and costs need to be developed against which to monitor the efficiency of computer provision. Four of these are suggested in this paper.
- Schools are likely to need assistance with planning and managing income generating activities if these are seen as a way of meeting running costs. Small enterprise development agencies may be an appropriate source of such assistance.
- The cost of computer provision in rural areas need not be prohibitively expensive. Data from *Myeka High School* suggests that this could be achieved in schools without mains electricity or landline connectivity for under $20 per student per year provided there are high levels of usage.

1. Introduction

Computers have been in schools in western countries for a quarter of a century. There are now few, if any, countries in the world that do not have at least one computer in at least some schools. The information revolution continues to gather momentum and wealth production is increasingly knowledge based. Yet the vast majority of schools in the world do not have any computers. Most of the world's teachers have yet to feel comfortable integrating their use into the curriculum in educationally productive ways. Substantial numbers, perhaps even the majority, of children have not seen and used a computer. Many, if not most, schools in the world lack grid electricity and landline telephones and the impact of computer usage in schools is unclear. Not surprisingly, the role of computers in education and the priority they should have in the allocation of scarce educational resources is an increasing important area in educational debate.

The main focus of this paper relates to the costs of computer provision for educational purposes in developing countries. Data relating to the costs of such provision is conspicuous by its scarcity. "We are short of the kind of cost data discussed … and have a particular need for studies that would set out the costs of achieving various communication technologies within developing countries" (Perraton and Creed 2000: 86). This paper gives glimpses into some of this data. It further touches on other issues relating to the successful provision of computers in schools, namely allocation processes and training.

The data on which this paper is based was gathered using a case study approach at a micro level. A framework was developed with five main categories through which to analyse cost data. Individual schools, telecentres and training providers were visited in Zimbabwe and South Africa during August 2000, the framework was explained to teachers, bursars and managers, many of whom used it to gather data and forwarded this for analysis and incorporation into this paper.

There are two main advantages to this approach. First, it is based on what has happened in individual schools and projects. It gives insights into actual costs that have been incurred rather than those anticipated by planners. Second, it is able to gather data from a greater range of providers than is available if just central ministry planning data is used. In addition to this, such an approach serves to complement the work undertaken by Bakia (2000) in her analysis of the planning documents from five different countries.

2. The e-revolution, costs and wealth production

The speed at which information can be processed, transmitted and stored continues to increase at rates difficult to comprehend. At the same time the costs of doing this continue to fall:

- Processing power has increased 7,000 fold in three decades.
- Transmission speeds have increased by a factor of nearly 200,000. Sending the 32 volumes of the Encyclopaedia Britannica on the internet from New York to San Francisco would have taken 97 minutes in 1970. Today eight full sets can be transmitted in one second.
- A single memory chip now holds 250,000 times as much data as in the early 1970s. This is equivalent to the difference between one page and 1,600 books.

(Federal Reserve Bank of Dallas 1999: 8)

Alongside this the costs of processing, transmitting and storing information also continue to fall:

- In 1970 Intel's chips sold at $7,600 per MHz., in 1999 their Pentium III chips were 17 cents a MHz.
- In 1970 sending 1 trillion bits of information cost $150,000, in 1999 it cost just 12 cents.
- In 1975 the cost of storing one megabit of information – enough for a 320 page book was $5, 257, in 1999 it was just 17 cents.

(Federal Reserve Bank of Dallas 1999: 8-9)

These factors combine to reduce production costs:

- Banking transaction costs on the internet cost banks an average of 1 cent each compared to $1.14 for face to face, pen and paper communication. Moreover travelling time to the bank and queuing while there (often substantial in many developing countries) are eliminated.
- By using 3D seismic technology the cost of finding a barrel of oil has been reduced from nearly $10 a barrel in 1991 to under $1 a barrel in 1999.
- In the United States studies show that telecommuting, working from home at least one day a month by using electronic links to the office, saves businesses roughly $10,000 annually for a worker earning $44,000.
- Sawmills using scanners and computers to optimise yield and value from each log enable a 30% increase in yield, thus keeping lumber costs down.
- Smart power systems in refrigerators mean they now require a third of the electricity they did in 1972.
- In 1985 it took $60,000 per slam to gather data on how cars performed in an accident. In 1999 the same crash could be simulated on a computer in 15 minutes for $200. By 2001 this will be reduced to $10.

(Federal Reserve Bank of Dallas 1999: 11-15)

Furthermore, the use of the internet, at the heart of the information revolution, is spreading through society faster than any previous innovation. One indicator of this is the time it has taken for innovations to attain a 25% share of the United States market:

Innovation	**Years to attain at 25% share of the US market**
Household electricity	46
Telephone	35
Television	26
PC	15
Cell Phone	13
Internet	7

(Merril Lynch 1999: 46)

However, access to these resources belongs to a privileged few:

- In 1999 in America 38% of households had access to the internet: in Africa as a whole the figure was 0.1%
- 62% of the world's telephone lines are installed in just 23 countries and serve 15% of the world's population, a quarter of the world's countries have less than one telephone per 100 people.

(Federal Reserve Bank of Dallas 1999: 11-15; Perraton and Creed 2000: 16)

In short, the new technology allows wealth producing activities to be undertaken in ever quicker and cheaper ways but so far the benefits of this accrue to a privileged few, making them still wealthier and so increasing the gap between rich and poor and at an ever increasing rate. This has become known as the digital divide. As Perraton and Creed observe "This 'digital divide' compounds existing inequalities between people within and between countries: the disparities in access are not random but correlate strongly with income, education, ethnic origin, location and gender" (Perraton and Creed 2000: 15).

3. Computers and education

There are two main justifications for the provision of computers in school-based education:

1. They can improve either the quality or the quantity (access) of education in a cost-effective way.
2. ICT is likely to play such an important part in the future of any economy, it demands its own distinctive place in the curriculum.

While these two justifications are inter-related, they also merit separate scrutiny.

Raising quality

The first is highly contentious. While what evidence there is indicates that giving computer access to students in schools can and often does improve performance, there has been no systematic research carried out in developing countries, which compares the effect of this provision against the alternative use of resources such as text books, basic furniture, teacher training or nutritional supplements which may also improve educational attainment. 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. The costs of ICT provision can be high in comparison to the costs of other equipment. ICT equipment can make high demands on well resourced schools. In under resourced schools – often farther away from mains electricity, landline connectivity and with increased travel costs for essential maintenance, these costs can be still higher. The opportunity costs in terms of other more basic educational resources can also be much greater than for well endowed schools where adequate resources can result in the marginal utility of these resources being reduced. However, in these situations the marginal utility of computers in such schools can also be much greater. Schools which are starved of resources and information can derive a much greater incremental benefit from a functional computer than schools already saturated with resources.

Increasing access

The case for ICT increasing access to education is also unproven. There may be a great potential for computer based learning at the post-basic level with even greater potential for computer assisted learning. However, such provision is likely to be in the more distant future. The software developments costs are colossal and effective demand is not likely to be large while those who have purchasing power are already served by good conventional schools. However, whether such developments can be used to increase the number of students that a teacher can effectively teach should be closely monitored, especially when in some countries the demands of Education For All (EFA) combined with the HIV/AIDS crisis will lead to even greater teacher shortages.

At the basic education level there is no evidence that the new technology can be used to increase access in a cost effective way. While current educational thinking advocates initial learning in the mother tongue, very few, if any, computer based learning materials are available in vernacular languages. In addition to this, basic education costs are usually very low: "The general conclusion is that primary education, at least in many LDCs has such modest unit costs that with the rarest exceptions, technology-based out-of-school projects cannot match them" (Perraton and Creed 2000: 73). However, when making such cost comparisons it should be noted that quoted unit cost figures for primary education rarely include the full costs of such provision. In particular they fail to include the costs or pre-service and usually of in-service teacher training.

Further arguments relating to quality and access

While these arguments lead to a scepticism as to the cost effectiveness of providing computer access to students in schools as a means of increasing access to education or of raising the quality of education provision three other arguments should also be considered:

1. There is little evidence that basic education as practised now in Sub-Sahara Africa can increase access and quality. There are many reasons to suggest this, one of which is that there simply is not the capacity to train and retain the number of teachers needed. The prevalence of HIV/AIDS makes this problem even more acute. School-based, computer-supported teacher training might be a part of the solution to this problem. Technology could make the pre-service training experience both better and shorter. It can also

enable ministries of education to send teacher trainees to schools sooner, as they can be supported using technology and the internet.

2. Providing computers in schools, whether to students or just to staff, can be a means of raising the status and interest of a profession that often suffers from low pay and low morale.
3. Providing a single computer and printer with web connectivity could be an effective tool through which to improve the quality of education by enhancing teacher effectiveness and improved school administration. While Perraton and Creed correctly point out that such provision shifts printing costs from the centre to the periphery and often to institutions little able to meet such costs, it is still the case that basic information and text books often fail to reach such schools. Even where full connectivity is not possible, the provision of data casting (see box entitled *"Infosat - Connectivity to the web without landlines?"* on page 33) or of information on CDs could be a low cost option which greatly enhances the resource base of teachers. While such provision must also include training and maintenance, it is likely to be cost effective in comparison to the current state of zero resource provision experienced by many teachers in rural schools.

A distinctive place in the curriculum

The second justification relating to the importance that ICT provision has in the curriculum is more compelling. This argument points out that during this century wealth creation will be increasingly knowledge based. If a country is to be internationally competitive it is essential that its labour force is able to utilise and harness the advantages of ICTs. If the education system fails to enable people to do this it also fails to meet the needs of the country and its economy. Those who propagate this argument acknowledge that there are problems associated with access and equity, that it is unlikely to be the poorest who will benefit from the provision of ICT in schools and that such provision could decrease equity within a country. However, if tomorrow's leaders, the managers and administrators of government, hospitals, schools and commerce, are not able to fully utilise the benefits of ICT, its population will be poorer as a result. Therefore, it is argued that it may be necessary to widen the in-country gap in order to prevent a further widening of the inter-country gap.

The exact role of ICT in the curriculum is less clear. Basic provision will often stop at the level of computer literacy so that students are able to use a word processing package, spreadsheets, database and surf the web. Some schools cannot offer all of this. Few schools or telecentres offer keyboard competency even though this can easily be acquired via a software package and can have a dramatic impact on the speed with which people can use other applications.

At a more advanced level ICT is integrated into different parts of the curriculum. Collaborative learning projects as advanced by IEARN (see www.iearn.org) and WorLD (see www.world-links.org) are one way to achieve this (see box below on Telecollaborative Learning). The aim is that students should acquire the information reasoning skills of retrieval, manipulation and appraisal of information and data, together with those of cross-cultural awareness and communication. These are the skills considered essential for success in the emerging knowledge based economy.

An example of this is Diocesan College (Bishop's) in Cape Town (see the Deluxe provision section on page 22). Here there is access to the web in all classrooms and students will surf the web, retrieve and appraise information as a part of ordinary lessons. The resources needed for the type of provision at Bishops are beyond all but the wealthiest schools in the world. However, this may give insights into some of the educational practices of the future. It is also worth remembering that prices do fall. In 1973 a basic calculator, with no memory, cost £100 (US$150) in the United Kingdom. In real terms this is possibly more than the cheaper PCs available today. Now a basic calculator, with memory, can be bought for a couple of dollars – less than the price of a text book.

In considering the place of ICT in schools, educators must have a clear understanding as to its educational role. "Pedagogy precedes technology" (Perraton and Creed 2000: 81). In the same way as literacy is not an end in itself - one does not learn to decode script for the sake of it but in order to do other things, so ICT is not an end in itself. It is, and can only be, a useful tool. Its mastery allows better data manipulation, information recovery, research and communication. The aim of education has to be to use it for this purpose. Education has to use technology to better prepare students for life. Teaching ICT skills does have its place in the way that teaching other skills such as writing and spelling do, but they are a means not an end. A failure to appreciate this leaves ICT as a solution looking for a problem to solve.

Telecollaborative learning: using ICT throughout the curriculum

In most schools ICT is taught as a discrete subject similar to others in the curriculum. When computers are used in other areas of the curriculum their use is often limited to enhancing presentation through word-processing and DTP. While this is valuable first step in helping students to acquire computer skills, it does not utilise the full potential of ICT to enhance learning throughout the curriculum. Telecollaborative learning, which literally means *sharing the labours of learning at a distance,* is a way of doing this.

What forms does it take?

Telecollaborative learning, also known as "collaborative learning", draws upon the rich traditions of project-based learning while inspiring innovative educational practices. Harris (1998)identifies three main types of telecollaborative activity:

Interpersonal exchanges: where participants "talk electronically" with others through email, Web-based discussion forums or audio/videoconferencing. Activities include: *Keypal Exchanges* – the online equivalent of the traditional "pen pal" exercise, *Global Classrooms* – in which two or more classes meet online for topical discussions and, *Telementoring* – student interaction with subject area specialists serving as mentors. All have a focus upon interpersonal communication.

Information collections and analyses: these activities emphasise research skills and analysis, encouraging students to move beyond the mere collection and exchange of data to engage in authentic, online interactions, which facilitate original ideas and thinking.

Problem-solving projects: these projects ask participants to use their interpersonal skills alongside their ability to collect and analyse information. Participants subsequently take actions that work toward the resolution of a social problem. Activities include: *Peer Feedback* – online workshops for students to critique their peers' work and ideas, *Parallel Problem Solving* – students in multiple locations work on the same problem using online interactions to discuss findings and problem-solving methods and, *Social Action Projects* – collaborative efforts to solve real world problems by moving beyond understanding to social activism.

An example

Students might undertake research work looking at "Sustainable Development". In such an investigation a class might initially devise a definition of Sustainable Development. They then present this, via the web, to students who are engaged in similar work in another part of the world. Following this initial research, students will engage in work which further develops their understanding, for example they might look at the different factors which help to make projects sustainable. They could subsequently look at projects in their community which are not sustainable and the measures which would be needed to rectify this. Students will then present their findings to other students in their partner school.

What are the benefits of telecollaborative learning?

Research indicates that when students share their learning with their peers in this way, rather that just with their teacher, a number of benefits occur including:

- Improved research and information skills
- Improved analytical abilities and higher order thinking skills
- Improved cross-cultural awareness and understanding
- Improved levels of presentation and communication
- Improved cross-linguistic communication skills

Information about ideas for collaborative learning and the mechanics of undertaking such work can be found at www.iearn.org and at www.world-links.org

Adapted from information provided by R. W. Burnside WorLD Professional Development Coordinator, April 2001. Also see Burnside and Monk (2001)

4. Costs of computer provision in schools: What we already know

Currently, there is little information relating to the costs of computers in schools, especially in schools in developing countries. In some ways this is not surprising. Computer provision has not been a priority as they are too expensive for most poor countries, many of whom struggle to provide text books. Furthermore, the prices are dynamic rather than static. Nominal computer prices are falling slowly. For many years a basic specification computer cost around $1,000 in the US and around £1,000 in the UK. However, over the last couple of years these prices have started to fall by 20 – 50%. Purchasing clones rather than brand name products can also bring similar savings. In real terms the fall in prices is even greater. However, the speed of technological developments is such that the capability and capacity of the computer purchased today is substantially greater than that purchased a couple of years ago. As shown in section 1, the price per MHz of processing speed and per bit of storage space has fallen dramatically. This makes the collection and analysis of cost data much harder. One way to accommodate this is to say that what is being purchased is the state of the technology at that point in time. To some extent this is a valid way of dealing with the problem as it is not possible to purchase the technology of a couple of years ago. Although the advances in technology mean that schools are now purchasing ever greater amounts of capacity and capability, most of which are not needed for basic educational uses.

However, as will be seen, the hardware and software costs of computer provision are only a part of the total costs. Housing, training, running and maintenance costs over the life of the computer are usually several times greater than equipment costs. Therefore, even if there is a 40% fall in equipment costs this can mean a much smaller reduction in the total cost of effective computer provision in schools.

There are two main studies which have been undertaken into the cost of computers in developing countries. One by Osin (1998) and the other by Bakia (2000), both are based on costs in middle income countries.

Osin's work on costs in Israel and his extrapolations for poor countries

Osin (1998) anticipates costs for the provision of 33 Pentium II 233 MHz computers with 32MB of RAM, server and auxiliary equipment in a primary school in Israel to be as follows:

	US$	Amortisation period (yrs)
New class room	30,000	40
Fixtures and furniture	20,000	12
Hardware, software and courseware, incld. internet provision	97,500	6
Teacher Training (60 hrs at $55/ hrs)	3,300	6
Total	**150,800**	

(Source: Osin 1998: 7)

Using an interest rate of 6% for amortisation gives an annual cost of $24,000. Recurrent costs are estimated as follows:

	US$
Maintenance	6,420
Upgrading software and courseware	2,000
Teacher training	3,300
Personnel (20 hours at $20, 52 weeks)	26,000
Internet	6,000
Total	**43,720**

(Source: Osin 1998: 7-8)

Adding this figure to the annualised investment cost gives a total of $68,620. To this Osin adds 10% for insurance, and contingency to give an annual total of $75,480. With 360 students in a school this would give a cost of $210 per student per year. Assuming facilities are available for 4 hours a day for 200 days a year, Osin, calculates a cost of $3.15 per hour. He then takes these figures and changes some of the assumptions for developing countries as follows:

- Halve building costs.
- Amortise equipment over eight years.
- Halve equipment costs by purchasing previous models.

Using these assumptions annual costs are reduced by 60% to $30,340 resulting in an annual per student cost of $84. Osin notes that this is in line with figures presented by Potashnick and Adams (1996) from research on Jamaica ($89), Chile ($104) and Belize ($78).

Osin proceeds to point out that if usage increased to 300 days per year, 10 hours per day with 30 PCs in use there would be 90,000 hours use per year with costs falling to $0.34 per hour. He remarks that there is no alternative system providing these possible benefits at just 34 cents / hour. All of these figures include VAT at 17%.

Osin's figures and the assumptions behind them need a brief comment:

1. They are projections, they are not based on what has actually happened. As such there is an air of unreality about them. New computer labs are rarely built – it is more common for existing classrooms to be adapted for computer use, often the local community finances and contributes voluntary labour to such refurbishment. Few of the schools offering computing facilities in developing countries do so with the array of equipment Osin itemises.
2. No planning costs are included – these are not a part of all programmes but could be expected to be a part of a programme of this type if it involves several schools.
3. While Osin adjusts building cost he fails to adjust the cost of personnel which in his figures accounts for 60% of total costs. Taking Israel labour market figures with no adjustment is misleading. Few, if any teachers in poorer developing countries are paid anything approaching $20 per hour.
4. Calculations are based on computer availability, not usage. The two are very different, in some situations one would guess that usage may only be 20% of availability. While it would be good if computers were used 300 days per year and 10 hours a day, the reality is that such usage is the very rare exception. Many schools fail to attain full usage of computers during school hours and few schools remain open for more than an hour or two after school and even less are open in the evening. It is also interesting to note that Osin does not budget for the extra staff time that would be needed for such extended usage.

This last point leads to a very serious issue. Research needs to be undertaken into current computer usage. Such research needs to include an examination of the barriers which prevent extended usage. It should also devise programmes to overcome these. Making better use of schools' existing computer resources would, in many countries, be a more cost effective way of increasing computer education than providing yet more under-used facilities.

Bakia's work on costs in Barbados, Turkey, Chile and Egypt

Bakia (2000) undertakes an analysis of data from four countries: Barbados, Turkey, Chile and Egypt. The first two are from country wide programmes and include central planning costs, the latter two look only at school based costs. These results are summarised in table 1.

Table 1: Main findings from Bakia's work on Barbados, Turkey, Chile and Egypt

	National Estimates		**School-based estimates**	
Cost Category	**Barbados**	**Turkey**	**Chile**	**Egypt**
Year	1998	1999	1995	1998
Central management	11%	2%	n/a	N/a
Hardware	33%	35%	49%	24%
Software	13%	6%	2%	2%
Facilities and renovation	19%	5%	3%	7%
Connectivity	10%	5%	10%	6%
Maintenance and technical support	18%	42%	n/a	4%
Professional development	4%	2%	13%	29%
Total annual cost	$30,279,100	$54,206,336	n/a	n/a
Total annual cost / school	$451,930	$21,685	$11,215	$45,045
Total annual cost / student	$646	$32	$56	$75

(*Source Bakia 2000: 20-21, Table 9). n/a not available*

Table 2: Students per computer for Barbados, Turkey, Chile and Egypt

	Barbados	**Turkey**	**Chile**	**Egypt**
Students per computer	3	40	68-137	27

(Source Bakia 2000: 11, Table 2)

Table 1 raises the question as to why the Barbados per student and per school costs are so much higher. By adding the second table we can see that a part of the reason is that Barbados plans to provide many more computers per student than other countries. Using this data together with data for Egypt, found in one of Bakia's annexes, it is possible to calculate the following figures for all of the countries apart from Chile where sufficient data is not provided:

Table 3: Further cost figures for Bakia's work on Barbados, Turkey, Chile and Egypt

Item	**Barbados**	**Turkey**	**Chile**	**Egypt**
Number of students	46,872	1,693,948	n/a	600
Number of computers	15,624	42,349	n/a	22
Cost per computer year	$1,938	$1,280	n/a	$2,048
Cost per computer over 5 years	$9,690	$6,400	n/a	$10,238
Cost of a computer	$2,000	$1,100	n/a	$1,600
Cost per computer over 5 years / cost of a computer	4.8	5.8	n/a	6.4

Figures calculated from the figures in the above tables and from figures in the annex in Bakia (2000). n/a not available

The *"cost per computer over 5 years"* is the estimated cost of effective computer provision over a five year period. This includes the costs of training, maintenance and support, as well as the cost of renovating existing premises. In the case of Barbados and Turkey the costs of central management and support is also included. It does not include either the salary costs of teachers teaching ICT, or the cost of building new premises to house computers, or the cost of electricity to power the computers. In Barbados, project preparation estimated at US$11,379,204 is included (Bakia 2000:8), this is equal to $242 per student.

The ratio of the *"costs per computer over 5 years"* to the *"cost of a computer"* suggests an average of 5.7. This indicates that on average it may takes a total of 5.7 times the purchase price of a new computer to ensure its effective use in a school over a five year period. Analysis of data from more countries installing new equipment needs to be made before it can be determined whether or not this is a useful rule of thumb.

It should be emphasised that these figures are derived from planning documents. It is not known whether these inputs bring about effective computer education for students. Critical to the success of such programmes are the processes involved in introducing computers to schools and the quality and timing of training for teachers.

It should be further emphasised that the data examined by Bakia relates to programmes undertaken by middle income countries purchasing state of the art computer equipment and with considerable amounts of money spent on support, maintenance, renovation, project preparation, etc. This model of computer provision is simply not an option for poor countries.

5. Costs of computer provision in schools: findings from this research

Research for this paper was undertaken in collaboration with the Human Development Network of the World Bank and with the World Links for Development (WorLD) programme. WorLD was initiated by the World Bank in 1997 and has two parts: WorLD, established as a part of the World Bank and operating within the World Bank Institute, the training arm of the World Bank, and The WorLD Organisation, an independent NGO spawned by and working alongside WorLD.

Choice of countries

Data for this paper was gathered during the course of visits to Zimbabwe and South Africa in August 2000. These two countries were selected for the following reasons:

- The WorLD programme operates in both countries and employs a co-ordinator in each country. This made it easier to gain access to different providers of educational computing facilities.
- At the time data needed to be collected, it was possible to visit schools in each of these countries during term time.
- It was thought that schools in these countries would be likely to keep accurate data of costs that could be easily accessed.
- The WorLD provision in Zimbabwe is through telecentres. This provides an interesting alternative model to single school based provision.
- Much of the published data currently available on computer costs in schools comes from middle and high income countries. Zimbabwe offers the opportunity to gather data from a low income country.
- South Africa, with its legacy of Apartheid, also has many poorly resourced schools in very poor areas. Furthermore, it is one of the more technologically advanced countries in Africa so gives insights into the technology which will become available in other countries during the next few years.

During August 2000 a total of 14 places or people were visited in Zimbabwe and 21 in South Africa.

Cost categories

In order to gain insights into the costs associated with computer provision in schools, a framework was developed in which to gather and analyse this cost data. Five main cost categories were included:

- ***Housing costs:*** the cost of having a watertight and secure building, supplied with electricity, adequate power outlets, suitable furniture and a phone line (where installed).
- ***Equipment costs:*** the costs of all hardware and software and their installation.
- ***Initial training of teachers:*** the costs of training teachers to be competent and comfortable in providing computer literacy training and in integrating the use of computers into other parts of the curriculum.
- ***Running costs:*** the costs of paper, ink, toner, electricity, telephone, ISP, maintenance, security and insurance.
- ***External support:*** including external technical and pedagogic support and any ongoing training.

A category for learning materials might be a useful addition to this list. These are an important part of computer education provision but are often neglected. Most are teacher produced and so would be included in running costs or in other parts of a school's budget.

Teacher costs

Not included in these figures is the cost of teachers' time. It was assumed that if students were not being taught ICT they would have been taught something else instead, therefore there would be no additional staff costs by having ICT as a part of a school's curriculum. The main focus of this study was on secondary schools. In some cases this assumption held true, in others it did not. Sometimes a class would be divided into two or three with half or a third of the students undertaking work on computers while other members of the class undertook other work. Such arrangements add to staff costs. In two of the three primary schools visited an additional member of staff was employed to teach computing. In one of these schools the normal class teacher accompanied the students to the computer lab and worked with the computer teacher. Where these additional costs occurred they have not been recorded in this work.

Why secondary schools?

The main focus of this research was to gain insights into the costs associated with computer provision in secondary schools. Initial computer provision is likely to be concentrated at secondary level in most developing countries for the following reasons:

1. Secondary schools generally have better infrastructure in terms of grid electricity, landline telephones and general accessibility for installation and maintenance than do primary schools.
2. If primary schools receive computers before secondary schools then primary school graduates are unable to maintain and develop their skills if they graduate to secondary schools without computers.
3. Secondary schools usually have larger budgets and are better able to meet the running costs associated with computer usage.
4. Secondary school graduates are more likely to enter the labour force at a level where computer usage is necessary.

However, it should be noted that anecdotal evidence from WorLD telecentre teachers in Zimbabwe who teach both primary and secondary school students, suggests that primary school students can often acquire the skills of keyboard competency and the ability to utilise many of the functions of word-processing and spreadsheets at least as quickly as secondary school students.

While the main focus of this work is on computers in secondary schools, visits were also made to primary schools, telecentres, and a commercial provider. The intention was to gain other benchmarks against which to reference the data from secondary schools.

Types of provision

From the visits made, there appear to be three main categories of school-based provision. These are as follows:

1. ***Basic provision***, uses second hand computers provided free of charge usually by a Non-Government Organisation (NGO) from the North. There is little or no back-up or support once the computers have reached the schools. Often these computers are provided to the poorest and most disadvantaged schools.
2. ***Basic plus provision***, also uses second hand computers provided by an NGO from the North. The computers have often been refurbished and upgraded to a minimum standard, usually by the addition of more RAM and a larger Hard Drive. Technical support and teacher training is also provided. The WorLD programme falls into this category.
3. ***Deluxe provision***, installs new equipment. There are usually two routes to this:
    1. *Well resourced schools* able to access substantial sums of money, usually in fees from parents or donations from benefactors.
    2. *Centrally financed government provision* where new equipment is installed in state schools.

Alongside this are two other categories of non-school based provision:

4. ***Community based telecentre provision,*** serves several different users which might include schools as well as the local community. Typically, usage is over more hours per week than single school provision.
5. ***Commercial provision***, where training and access are provided by the private sector on a break-even or for-profit basis.

In addition to this ***rural areas*** without either grid electricity and/or landline telephone connectivity provide a separate set of challenges and costs. Such provision could fall into any of the above five categories, although as demand is likely to be low there is unlikely to be commercial provision in rural areas. In this paper two such examples are examined one, *Myeka* is school-based and is reviewed separately, the other, *Kgautswana,* is community based and included in the C*ommunity based telecentre* section.

These are not rigid categories. Some schools do not fit easily into any of these categories, but categorisation in this way aids analysis. Neither should it be assumed that all basic provision schools have inferior provision. The computers in some of these schools are maintained by teachers who have considerable technology expertise and who somehow manage to provide a high level of provision, especially when considering the equipment and limited resources they work with. However, it also has to be acknowledged that many basic category schools struggle hard to maintain and provide even basic computing facilities.

A case study approach is used to give glimpses into the provision of each of these categories. Cost data is only presented and analysed for school-based provision.

Basic provision

Basic provision uses second hand computers provided free of charge to the school. They are often supplied by an NGO from the North with little back-up or support. These computers are usually provided to the poorest and most disadvantaged schools.

The schools

Four schools were visited which fell into the basic category, they are all state schools.

- ***Harare High School,*** Zimbabwe, is in a "high density" part of Harare and operates a double shift system. The termly levy of Z$50 (US$1.25) means that it is children from poorer families who attend the school. Currently, 76 of the school's 1,650 students use the four 386 and one 486 second hand computers with 57 doing so on a regular basis. All machines operate old DOS based software. Financing repairs to the computers strains the school's already stretched finances and means delays to repairs. The school is able to generate an income of US$240 a year from computer classes held in the evenings.
- ***Mutoko High School***, Zimbabwe, is 150 miles from Harare, in a rural area. It has 780 students aged 12-18. 40% of students are boarders. Fees average Z$2,000 per term (=US$50 or US$150 p.a.) for day students and Z$7,000 (=US$175 or US$525 p.a.) for boarders. The school initially had eight computers – 386s and 486s operating as stand-alones. These were donated by Africtec – a Canadian NGO. Eleven more computers had arrived on the day prior to our visit and these are included in the cost data below. Students use the computers during free lessons and in the afternoon when there is no teaching, so the lab is used from 8 a.m. to 5 p.m. Initially only 80 of the top year students used the lab with up to 25 students doing so at any one time. With the provision of additional computers there is now greater usage. The figures provided below reflect the increased provision and usage. The school has also built a new computer lab to house the additional computers. This was financed with money raised from parents. In addition to this Afritec have arranged with World University Service of Canada (WUSC) for a Canadian Volunteer to work at *Mutoko* for six months. This additional input may have been at least partially responsible for the dramatic increase in usage at *Mutoko.*
- ***Sinethemba High School,*** Western Cape, South Africa, (www.wcape.school.za/sinethembass/) serves one of Cape Town's townships and has 1,750 students. School fees are R80 (US$13.3) per year. The school has 21 donated computers: eight 486s donated by Computer Aid, a UK NGO, eight Pentium175s donated by Cape Mail and five Pentium 266s donated by the rotary. These are networked with a Pentium 166 server donated by Telkom. This network is only kept operational by the high level of technical expertise of Mr. Lindert, the school's Vice-Principal. At *Sinethemba* 18, of the school's 51 teachers use the computers.
- ***Yomela Primary School,*** Western Cape, South Africa, enrols 800 students from one of Cape Town's townships and has 21 teachers. School fees are R50 (US$8.3) per year. *Yomela* has 20 computers. These are 486s with 8MB of RAM donated by Computer Aid and re-furbished by students at Athlone Technical College. They are networked and run by a 486 server. About 400 students pay R25 (US$4.1) per month for computer lessons. This is used to pay for the salary of the school's computer teacher, who was hired as an additional staff member to teach computing. Students use educational software on the computers which do not have word-processing or other applications.

In addition to the fees mentioned above, parents may pay around Z$500 (US$12.5) for school uniforms in Zimbabwe and R600-800 (US$100 - $133) in South Africa. Transport to and from school is a further cost.

The data gathered

Data on costs have been supplied by *Harare* and *Mutoko High Schools* in Zimbabwe and by *Yomela Primary School* in South Africa. Complete sets of the data submitted can be found at www.world-links.org

Table 4: Gathered cost data for basic provision

	Zimbabwe		**S. Africa**
Item	Harare High	Mutoko High	Yomela Primary
Summary of data gathered			
Housing: refurbishment, fittings and furniture	$1,567	$15,452	$7,483
Equipment: hardware and software	$1,190	$1,201	$5,176
Annual training cost	$15	$4,088	$8
Annual running cost	$1,160	$4,039	$2,221
Annual external support cost	$250		$0
Number of computers	5	20	20

Clearly the start up costs of refurbishing a classroom and getting the initial equipment together are a large proportion of costs for poorer schools. At *Yomela* about $2,500 (33%) of the housing costs were funded by parents and the community, the rest was met by donors. All equipment costs were met by various donors. The 20 computers donated free of charge by Computer Aid International (CAI), cost $960, less than 20% the equipment costs. At *Harare High* virtually all housing costs were met by parents and the community. The computers were donated free of charge by local business, a cost has not been imputed for these. Virtually all of their other equipment costs were met by donors with just over 10% being donated by businesses. At *Mutoko High* the high housing costs include about $12,700 to build a new computer lab and $2,300 for the mains wiring.

These case studies show that for poorer schools initial set up costs may be "free" in terms of demands on the school's budget, but that skills, time and contacts are needed to harness resources from parents, the local community and donors. At least one, and usually several "champions", of computers in the school are needed to do this work. They also indicate that computers in schools are something which parents, even in poorer areas, want and are prepared to give time and money to obtain.

Little is spent on computer training of staff in these schools, apart from at *Mutoko* where it is estimated that around $4,000 has been spent on training – a figure which may be on the high side. This may reflect a general absence of resources for staff training in these schools. As a consequence there is little integration of ICT into the school's curriculum. Often, there is a qualified and trained teacher of ICT who teaches this as a subject. Alternatively, there are some teachers who have an interest in computers, have gained some expertise and offer this as an extra-curricular activity.

Unit cost data

When data on usage is added to the above data, unit costs can then be calculated as shown in table 5.

Table 5: Unit Cost data for basic provision

	Zimbabwe		S. Africa
Item	Harare High	Mutoko High	Yomela Primary
Summary of user data			
Number of students in the school	1650	740	800
Number of "regular" student users	57	740	400
% of students with regular use of computer	3%	100%	50%
Number of regular users (students, staff & community)	78	810	442
Total number of users (regular and non-regular)	105	788	442
Calculated cost data			
Annual cost of computers in school (excluding teaching costs)	$1,794	$9,655	$3,887
Annual cost per regular student user	$31.47	$13.05	$9.72
Annual cost per user	$17.09	$12.25	$8.79
Annual cost per computer	$359	$483	$194
Cost per computer over 5 years	$1,794	$2,414	$972
Efficiency of usage calculations			
Possible number of regular student users	250	1000	1000
Actual regular students as % of possible regular student users	23%	74%	40%
Possible number of regular users if open 10 hours, 300 days	375	1500	1500
Actual regular users as % of possible regular users	21%	54%	29%
Hypotheticals			
Annual cost per regular *user* if 80% efficiency usage	$3.83	$5.15	$2.07
Annual cost per regular *student* user if 80% efficiency usage	$5.74	$7.72	$3.11

Note:

1. See appendix 1 for calculations of *"Possible number of regular student users"* and for *"Possible number of regular users if open 10 hours, 300 days"*
2. *"..80% efficiency usage"* is 80% of the possible number of *"regular student users"* or *"regular users*" as calculated in appendix 1

The *"annual cost of computers in school"* includes annual running costs as well as a twelfth of housing costs and a fifth of equipment costs. As has been seen, the school bears few of these "capital" costs itself but must have the capability to mobilise / access resources to meet them. The figure is considerably higher at *Mutoko* due mainly to the high amount spent on training, which has been counted as an annual cost. In addition to this *Mutoko* has just been connected to the web and running costs of around $3,000 have been estimated for this (see appendix 4).

The *"annual cost per regular student user"* is comparatively high at *Harare High.* This is largely because the *"actual student users as a % of possible regular student users"* is low. An additional factor is that the initial start up costs of housing together with most of the equipment costs are spread over fewer computers. The figure of 21% for *"actual regular users as a % of possible regular users"* indicates that *Harare High* could enable five times as many students to use its computers on a regular basis than is currently the case. At *Yomela* there is the capacity for two and half times as many students to use the computers than do so. Students' parents pay $4 per month for access, which pays the salary of the specialist teacher. Not all students' parents can afford this. Unfortunately, the fees needed to ensure that computers are available for some to utilise also act as a barrier to others. It further means they are not as well utilised as they could be. At *Mutoko* these costs are comparatively low in spite of the high housing costs due to the high usage.

The hypothetical calculations indicate that with 80% efficiency of usage the cost per regular student user could be as low as $3.00 per year for basic provision. However, this does not include the cost of staff time and it is important to realise that other high cost inputs, such as training, are likely to be needed in order to achieve a higher level of usage in the most educationally effective way.

Cost comparators and ratios

Table 6: Cost comparators and ratios for basic provision

	Zimbabwe		**S. Africa**
Item	Harare High	Mutoko High	Yomela Primary
Cost comparators			
Cost of a Grade 9 text book	$12.50	$12.00	
No of text books for annual cost of computer provision	144	805	
Cost of Newly Qualified Teacher (NQT)	$3,000	$4,350	$9,000
No of NQTs for annual cost of computer provision	0.60	2.22	0.43
Ratios			
Cost per computer over 5 years	$1,794	$2,414	$972
Cost of a computer	0	27.67	48
Cost per computer over 5 years / cost of a computer		87.2	20.2

The calculation of cost comparators gives an idea of the opportunity cost of computer provision of this type. At *Harare High* instead of giving regular computer access to 57 students as is presently the case, or to 250 students as could be the case with more efficient usage, the school could purchase 144 more text books or perhaps employ an additional teacher for nearly three days a week. At *Mutoko* the resources used for computer provision could be used to purchase 800 text books each year or to employ two additional teachers. At *Yomela* such a teacher could be employed for a couple of days a week. Clearly, decisions have to be made about the best use of educational resources. However, it should also be noted that many of the resources which are donated for computer education might not be donated as easily for other uses. The provision of computers in schools has the ability to harness additional resources for education more easily than many other inputs.

The ratio of the *"cost per computer over 5 years / the cost of a computer"* is particularly high due to the low cost of refurbished computers as supplied by an NGO. It is, however, an indication that the cost of the computer is only a small part of the total costs of provision.

Conclusions

From these glimpses into basic provision it appears that:

- Where there are facilities, usage is low compared to what is possible. Increasing computer usage could, therefore, be the best way to reduce unit costs.
- Provision for training teachers in the use of computers is very low and there is little integration of ICT in the curriculum. In order to change this, resources will be needed for teacher training.
- Parents, students and teachers want ICT in schools and are prepared to pay for and work for this. Donors and policy makers need to build on and complement this desire in ways that will enhance such provision.
- Skills, time and contacts are needed in order to harness provision at the basic level.

Second-hand / refurbished computers.

For many poorer schools and countries the option of buying new computers is prohibitively expensive. Using second hand computers can be a practical and affordable alternative.

While such equipment is not the latest and most powerful in computing terms it can still be functional for educational purposes. In ICT education, students need to acquire a range of skills, including how to learn about different software packages. To do this the latest hardware and software is not needed. Software is changing all of the time. Most students will need to learn how to use new application before they reach the labour force. This will also be a part of their working life. Learning how to learn about ICT does not need the latest equipment.

There are several NGOs that have been established in Europe and America to recycle computers to developing countries. The following are some examples.

Computer Aid International is based in the UK (www.computeraid.org). Since starting operations in 1997 they have provided 5,000 recycled computers to schools and community organisations in 33 developing countries.

The total cost of shipping a container with 220 computers to Southern Africa in September 2000 was about US$10,560. This works out at US$48 per machine but does not include transport costs to the school from the in-country freight terminal. The machines are supplied free of charge to the schools.

During 2000 the minimum specification of computers provided by Computer Aid has been 486s. 50-60% of the computers in the workshop in October 2000 were Pentiums or 486 Dx2s capable of running Windows 95 and MS Office. During 2001 it is likely that Pentiums will become their minimum specification.

Computer Aid currently supplies around 100 to 200 computers per month. They are confident that with adequate funds they could expand to around six times their present capacity. That is 500 – 800+ units per month.

Computer Aid is currently supplying all 187 high schools in Swaziland with a networked computer lab of:

- 19 PCs - 486 minimum spec
- 1 Pentium 133 with internal 56-band modem, 56 speed CD-ROM, soundcard and speakers
- 1 printer.

Afritech is a Canadian based NGO which also recycles computers from corporate users. Afritch pays $27.67 for the motherboard of each computer to be professionally checked. Sometimes the person doing this is able to add additional RAM but there is no minimum specification of the computers shipped out. This is the only cost incurred by Afritech as all other labour and warehousing are donated free of charge. Afritech also redistribute other learning resources. They intend to increase the size of their operations to achieve a through put of 200 – 400 computers per year. Computers are provided free to schools.

The WorLD Organisation is a Washington based NGO (www.worldbank.org/worldlinks), spawned by the World Bank. They are able to supply used ex-rental machines from large computer manufactures (US specification) at the following price:

- Pentium 200, 32Mg RAM, 1.2 GB hard drives, CD-ROM, $265 without a monitor or $400 with a monitor. The minimum order is 150 machines with a monitor or 300 without. There is no software, Windows 97 is $88 extra (July 2000 prices).

Basic plus provision

This uses second hand computers provided by an NGO from the North. The computers have usually been refurbished and upgraded to a minimum standard. Unlike basic provision, technical support and teacher training is also provided. The WorLD programme is an example of this category.

The schools / telecentres

The case studies in this category are all provided by WorLD (World Links for Development) which is a combination of the WorLD programme of the World Bank and the WorLD Organisation – an NGO it has spawned.

WorLD operates two different models in the countries visited. In Zimbabwe WorLD centres are telecentres serving a number of schools and a variety of other users. They tend to be open for longer hours than computer labs serving just one school. Some of the telecentres are based on a school site while others are not. Three such centres were visited during the course of this research. In South Africa the WorLD computer labs are all school based, two of these were visited during the course of this research. However, one of these schools, *Micha-Kgasi,* was subsequently provided with a lab of 20 new, state of the art, computers and so is included in the deluxe category. In both Zimbabwe and South Africa the WorLD computer labs usually comprise of ten 486 computers, a server, printer and other periphery equipment and have web connectivity.

- ***High Glen Telecentre,*** Harare, Zimbabwe, is housed in a former school annex in a "high density" suburb. Thirty two schools use the centre with 400 students per week for 40 weeks of the year having a "taster" course on computers for two hours. This means that 7,800 students use this facility each year. Some of these students then book further computer courses and access time during the school holidays and community sessions. There are 35 teachers and 40 students who also use the centre on a regular basis for a few hours each week. *High Glen* further runs courses during the school holidays for 30 teachers at a time from each of the seven districts. The centre generates income of about US$5,400 per year. It is likely that this comes from user fees charged to all users including the schools and school students who use it.
- ***Marondera Telecentre,*** Zimbabwe, is housed in a high school 70Km from Harare. The centre serves seven schools with students attending for two hours once a fortnight for two terms. Students therefore receive 26 hours of computing per year. On average 840 students can access this level of provision each year with students working in pairs at each computer. Students learn word-processing, spreadsheets and how to access information from the web. The lab has 13 computers. Our visit was made during an afternoon "community" session. The lab was being used by students mainly to email friends and relatives overseas. Students pay an additional amount for such usage. A music teacher was also using the web for research purposes. Marondera generates about US$1,200 from user fees.
- ***Bindora Telecentre,*** Zimbabwe, is housed in the regional government's office, 90 Km from Harare. The centre is used by five secondary and three primary schools per week, with 180 school students using the facilities each week for two terms. Another tranche then replaces them. During this time students will utilise between 48 and 120 hours of computing time. They are taught basic computer operation, word-processing, spreadsheets, sending emails and accessing information on the web. There are ten networked 486, 66 MHz computers in the lab, each has 32MB of RAM and a 600 MB hard drive. They are linked to a Pentium III server. The Telecentre is open from 8 a.m. to 6 p.m. on weekdays and is often used by Zimbabwe Open University students during the week-end.
- ***Ngaka Maseko High School,*** South Africa, is in a township 35 KM from Pretoria. The school has 1400 students in grades 10-12 and 38 teachers. Students pay R110 (US$16) in school fees to attend each year. Classes are from 8 a.m. to 2 p.m. or to 3 p.m. for grade 12s. The school has ten 486 computers. ICT is not a time-tabled subject in the school but students use the computer lab for project work in different subjects. Once students start to send and receive emails they become more interested in collaborative learning projects. One of the main barriers to further integration of ICT throughout the curriculum is teachers' fear of using computers: "Some are frightened that they will explode if they press the wrong key" (personal communication, Mmabatho Mosuoe, technology teachers and member of ICT committee, *Ngaka Maeseko High School*, 11/8/00).

The data gathered

Data from the basic plus telecentres and schools visited is as follows:

Table 7: Gathered cost data for basic plus provision

	Zimbabwe			S. Africa
Item	High Glen Telecentre	Marondera Telecentre	Bindora Telecentre	N. Maeseko High School
Summary of data gathered				
Housing: refurbishment, fittings and furniture	$4,494	$3,668	$0	$3,560
Equipment: hardware and software	$6,085	$6,295	$5,835	$5,434
Annual training cost	$1,649	$1,649	$1,649	$3,094
Annual running cost	$3,610	$4,467	$5,193	$700
Annual external support cost	$7,742	$7,742	$7,818	$5,433
Number of computers	10	13	10	10

The absence of *housing costs* at *Bindora* may be due to the telecentre been housed in a third floor room in the regional government offices. This eliminates the need for expensive security measures and with the desks and chairs already there, housing costs are minimised. At *High Glen*, *Marondera* and *Ngaka Maeseko* these costs were met from resources raised by parents and the local community.

Between 80% and 90% of *equipment costs* were met by the WorLD programme. About 40% (US$2,500) of this cost relates to the computers and about 30% (US$1800) to the server. For the programme in South Africa, some of this equipment, including the servers, were donated by other donors or commercial organisations.

In all of these case studies it has been very difficult to estimate accurately *training costs*. The costs represented above are the unit costs for the training provided by WorLD. For Zimbabwe the figure is based on training for two teachers at each of the centres during a year. At *Ngaka Maeseko* this cost is higher as four teachers have been trained. These teachers then passed on these skills to three of their colleagues. However, it should be emphasised that this is a *marginal cost* figure and not the *total cost* of such training. It does not include the costs of course development and general training support from WorLD in Washington, this is included in the cost given for external support. Many teachers also pay for themselves to attend courses in the use of applications such as word-processing and spreadsheets. Six teachers at *Ngaka Maeseko* have learnt to use computers in this way at a cost to themselves of between US$150 and US$300, depending on the modules they have registered for.

The *external support* costs largely relate to support provided by WorLD. There are two parts to this. The first represents the central support costs of the work undertaken in Washington, DC. A figure of US$5,802 for each centre in Zimbabwe and US$3,315 for each school in South Africa has been used. This has been calculated by taking the annual costs associated with the WorLD programme in Washington, dividing this by the number of countries with a WorLD programme and then dividing this figure by the number of telecentres or schools supported in that country. The second element is the in-country costs of the WorLD programme. This is the central budget for that country divided by the number of centres supported. This has been calculated as $1,940 per centre in Zimbabwe and $1,059 per school in South Africa. Much of the work undertaken by WorLD in Washington and in individual countries goes into developing and running training courses, and to providing technical support to centres.

The *annual running costs* include the costs of all paper, ink and toner as well as items such as floppy discs, maintenance costs and the wages of a security guard when one has been hired because of the presence of the computers. For the Zimbabwe centres the annual costs of phone calls for web connectivity has also been included. These vary between US$150, $670 and $1080. This variation occurs due to usage and the distance from the Internet Service Provider (ISP). *Bindora* has the highest costs. It is further from the ISP and has to pay a long distance rate for phone calls in order to be connected to the web. *Bindora* also pays US$750 in fees to the ISP which the other centres have so far managed to avoid. For *Ngaka Maeseko* a cost of US$134 has been given for computer related telephone usage.

Unit cost data

Table 8: Unit cost data for basic plus provision

	Zimbabwe			S. Africa
Item	High Glen Telecentre	Marondera Telecentre	Bindora Telecentre	N. Maeseko High School
Summary of user data				
Number of students in the school /schools served by T'centre	n/a	5070	7200	1400
Number of "regular" student users	40	799	500	100
% of students with regular use of computer	n/a	16%	7%	7%
Number of regular users (students, staff & community)	177	919	830	112
Total number of users (regular and non-regular)	8077	1344	1375	838
Calculated cost data				
Annual cost of computers in school / telecentre	$14,593	$15,423	$15,826	$9,552
Annual cost per regular student user	$364.83	$19.30	$31.65	$95.52
Annual cost per user	$1.81	$11.48	$11.51	$11.40
Annual cost per computer	$1,459	$1,186	$1,583	$955
Cost per computer over 5 years	$7,297	$5,932	$7,913	$4,776
Efficiency of usage calculations				
Possible number of regular students	500	650	500	500
Actual regular students as % of possible regular students	8%	123%	100%	20%
Possible number of regular users if open 10 hours, 300 days	750	975	750	750
Actual regular users as % of possible regular users	24%	94%	111%	15%
Hypotheticals				
Annual cost per regular *user* if 80% efficiency usage	$15.57	$12.65	$16.88	$10.19
Annual cost per regular *student* user if 80% efficiency usage	$23.35	$18.98	$25.32	$15.28

Note:
1. See appendix 1 for calculations of *"Possible number of regular student users"* and for *"Possible number of regular users if open 10 hours, 300 days"*
2. *"..80% efficiency usage"* is 80% of the possible number of *"regular student users"* or *"regular users*" as calculated in appendix 1
3. n/a = not available

As with the other categories the *"annual cost of computers in the school / telecentre"* includes annual running and support costs as well as a twelfth of housing costs and a fifth of equipment costs. Training costs are also included and have been taken as an annual cost.

The *"annual cost per regular student user"* works out to be under $20 at *Marondera* and just over $30 at *Bindora*. For *Ngaka Maeseko* it is considerably higher and is over $360 at *High Glen*. The difference in these figures arises from different levels and patterns of usage. *High Glen* has opted for a different usage pattern which enables a high number of students (over 8,000) to have a "one-off" computer experience. The educational value of this seems questionable. At *Ngaka Maeseko* the figure results from much lower all round usage. This again indicates that a fruitful area for new research could be to examine the barriers to maximum usage of existing computer facilities and how these could be reduced.

The *"annual cost per computer"* is between $1,000 and $1,600. This is four to five times the cost of similar *"basic*" provision but the increased usage which may result, combined with the probability of a better educational experience for students as a result of their teachers having benefited from WorLD training, may mean that this is a good use of resources. It could also be the case that this cost might be reduced over time. Once sufficient teachers have been trained and once patterns of high usage have been established they are likely to remain, even with much reduced external support from WorLD.

It is also worth noting that two of the Zimbabwe telecentres enable "regular" usage at or above the suggested theoretical benchmark for maximum regular usage. Usage above the "maximum" is possible due to extended hours of usage and due to different usage patterns. At *Marondera* students attend fortnightly, but are still able to develop their skills through such usage. At *Bindora* students have formal lessons for two terms and then continue their work in "community" time, this means that over a two year period three tranches of students are trained in computer usage rather than the two who would be trained on an annual cycle. The high level of regular student usage in these centres shows that the benchmark of 80% of the maximum "theoretical" usage is attainable.

Cost comparators and ratios

Table 9: Cost comparators and ratios for basic plus provision

	Zimbabwe			**S. Africa**
Item	High Glen	Marondera	Bindora	N. Maeseko
	Telecentre	Telecentre	Telecentre	High School
Cost comparators				
Cost of a Grade 9 text book	$8.00	$8.00	$8.00	n/a
No of text books for annual cost of computer provision	1824	1928	1978	n/a
Cost of Newly Qualified Teacher (NQT)	$4,393	$4,393	$4,393	n/a
No of NQTs for annual cost of computer provision	3.32	3.51	3.60	n/a
Ratios				
Cost per computer over 5 years	$7,297	$5,932	$7,913	$4,776
Cost of a computer	$250.00	$250.00	$250.00	$210.00
Cost per computer over 5 years / cost of a computer	29.2	23.7	31.7	22.7

Note:
1. n/a = not available
2. The data for the cost comparators was only provided by Marondera but has been taken as appropriate for the other Zimbabwe centres

The data on *"cost comparators"* depicts the choices policy makers face. In Zimbabwe the resources needed for the provision of a telecetre with ten computers could be used to provide around 2,000 text books or three and a half Newly Qualified Teachers (NQTs). In fact, in the case of the telecentre model used in Zimbabwe the costs of provision do not include the cost of the two teachers, which is an additional cost. As these are experienced teachers it is fair to assume that their salary would be higher than that of a NQT. Therefore, such resources could be used to provide about six (3.5 + 2) additional teachers or 3,000 additional text books per year. In making such a decision policy makers need to look at these costs alongside the benefits which they estimate flow from the different options. Research being commissioned by WorLD will help policy makers to make these estimates in a more informed way. However, as has previously been noted, it should be borne in mind that not all of the resources utilised for computer education at the basic plus level will be available for other educational usage. Parents, businesses and the community are willing to meet some of the costs of computer education in a way which they are more reluctant to for the provision of other educational resources. The same applies to funds raised by Northern NGOs to finance their work.

Conclusion

From these glimpses into *basic plus* provision it appears that:

- The higher costs of *basic plus* provision may result in higher usage of computer facilities. This appears to be the case in Zimbabwe but it is not possible to know if this is due to the additional inputs of the WorLD programme or due to provision through a telecentre model. The little data gathered in South Africa where usage appears to be much lower in WorLD schools may indicate that it is due to the telecentre model.
- Much of the recurrent costs of computer usage at the *basic plus* level is funded through users fees. This "willingness to pay" indicates that computer provision is valued by parents and students.
- The higher cost of the WorLD programme may fall as sustained support may not be needed once sufficient teachers are trained. High usage patterns once established are also likely to be self-sustaining.

NewDeal: - give new life to old computers?

NewDeal is a software package that can be run on any computer from a 286 to the newest Pentiums. NewDeal claim their product outperforms every other desktop operating system and application suite. It is constructed in a way which allows very small application size and very fast performance.

Company propaganda indicates that: *NewDeal Office is the only integrated point-and-click application suite - including word processor, spreadsheet, database, personal finance, drawing, web browser, email, chat and web editing programs - able to run effectively on ANY PC, from the latest Pentium III to the earliest 286 PC. It can be run on standalones or networked and will run from DOS or any version of Windows, OS/2 or Linux* (See www.newdealinc.com)

At a cost of around $70 this can be a highly cost effective way of using refurbished machines to bring full functionality and connectivity to schools.

NewDeal is gaining a following with some people equipping schools in poorer countries. Mike Trucano, a consultant with World Links for Development writes about his recent experience of NewDeal.

"Last week I spent a day with the international rescue committee's refugee resettlement centre in Baltimore. They had received some donated computers, and were looking to refurbish them and get them out to refugee families. As the computers were old (x386s, with 2MB of RAM and hard drives under 100MB), I suggested they install NewDeal software on them. They did, and it worked wonderfully!

What is it like? *It looks and feels like windows, and is much easier for a first-time user of a computer to use than windows is. I was able to import Word and Excel files fairly easily - the browser was pretty primitive, but I was able to bring up most web pages without too much difficulty (although things like Java, Javascript, etc. were a big problem)*

Notes on installation *- the installation process was very smooth - NewDeal installed easily on top of DOS (no versions of windows were installed). I installed NewDeal successfully on a 386 with 2MB of RAM (it had previously been used as a "dumb" terminal) - new loaded via diskette (7 of 'em) in about 40 minutes - I had to go find a driver for the mouse, as the donating company had stripped out "all" software on the computer except for DOS (this is something to remember if we are giving advice on refurbishing computers: don't forget to get a copy of a basic mouse driver - NewDeal is difficult to use without the mouse!!)*

Final thoughts *- I am really a big fan of this product. It "brings to life" old computers with a windows-like look-and-feel and functionality (office suite, browser) - while I wouldn't put this on a new computer, on old donated equipment this is the way to go!"*

(Mike Trucano, Consultant, World Links for Development, October, 2000)

Deluxe provision

Deluxe provision uses new equipment and is purchased either by well endowed, often private schools, or through a central government programme for the provision of computers in schools.

The schools

Five schools were visited which came into this category:

- ***Prince Edwards School,*** Harare, Zimbabwe, is a state school with fees of Z$17,600 per term (US$440 per term = US$1,320 p.a.). This means that it is attended by children from relatively wealthy families. *Prince Edwards* has 65 Pentium III computers operating MS Office 2000 which are housed in purpose built labs. Furniture has also been specially designed and built for the computer labs. These facilities have been financed by a school appeal and a substantial donation by a former student. Currently, 600 of *Prince Edward's* 1300 students use these facilities. Computers are expected to be replaced every three years. The school employs its own technician to maintain the equipment. About 40% of the students using the computers have access to computers at home.

- ***SOS Primary School,*** Harare, Zimbabwe, enrols 840 students some of whom travel up to 30 Km to attend. The current fees are Z$6,750 (US$169 per term = US$507 p.a.). Included in these fees is Z$500 (US$12.50 = $37.50 p.a.) to finance the computing facilities. About 12% of students have access to a computer at home. While the fees are high by Zimbabwe standards 120 of the students come from the SOS village for orphaned children and about a third come from "high density" areas. There are also 20 scholarships for needy children. The school is part government and part private with the government paying the salaries of two thirds of the teachers on account of the attendance of the orphaned children. The computer lab visited had 15 Celeron 300 computers with 32 MB of RAM and 3 GB hard drives (cost US$1,125 each). The computers worked in a pier to pier network which was making it difficult to protect the software. Forty students were using these facilities, working with three students per computer and were largely absorbed in their word-processing activities. These computers have since been moved to a new purpose built lab where fourteen refurbished 486s with 32 MB of RAM and 4.2 GB hard drives have been added (cost US$842 each). The figures for costs are based on this new lab.
- ***Diocesan College (Bishops),*** Cape Town, South Africa, (www.dc.wcape.school.za/) is a private college financed from the fees it charges and its endowments. *Bishops* integrates ICT into all aspects of the curriculum. The school has its own fibre-optic intra-net with 25 access points in each classroom and 780 such access points throughout the school. About two thirds of students have lap-top computers (US$1,500 – $2,000 each). These can be used to surf the web for research purposes during lessons and study. Much of the college's curriculum is kept on its intranet. *Bishops* also runs a programme to give computer access to about 100 students without these facilities who are tutored by Bishop's students. The college has two labs each with 25 networked computers. It also has 20 computers in its library. Bishops aims to replace their equipment every three years.
- ***Alexander Swinton High School,*** Cape Town, South Africa, (www.wcape.school.za/sinton/) is a state high school. It is of particular interest as it operates 25 computers on a "thin client" network. This system means there is only one server which feeds the other dummy terminals. These dummy terminals do not have any moving parts and contain only solid state electrical circuits. As a result they should not need any maintenance and should use much less electricity – something that could be of particular interest for provision in schools without grid electricity. Such systems may also be cheaper. Bakia gives prices in the US of US$499 to purchase or $9.99 per month for a five year leasing contract (Bakia 2000: 11).
- ***Micha-Kgasi High School***, South Africa, is in a village about 35 KM from Pretoria. The school has 690 students and 21 teachers. There are two computer labs. The first was installed by WorLD and has eight to ten 486 machines. The second, was supplied by the government through the Universal Services Agency (USA) (see Appendix 2) and includes 20 new Pentium III, 466 MHz computers with 64MB RAM and 4.3 GB hard drives. These are networked to a server with 256 MB of RAM and a 20 GB hard drive. This second lab is also air conditioned. Students have ICT as a time-tabled subject where they learn different applications. Due to technical problems with Telkom, the DECT phone link does not have enough bandwidth to provide connectivity to the web. With the provision of the new computer lab, *Micha-Kgasi* has been classified as having deluxe provision. Some of its teachers have also benefited from WorLD training. An estimation of these training costs have also been included in the cost data.

The data gathered

Cost data was provided by SOS and Bishops. The data used for *Micha-Kgasi* is a combination of that provided by the school and by the Universal Services Agency (USA) who were responsible for the procurement and installation of the computers on behalf of the government. *Prince Edwards* also provided cost data but due to difficulties in clarifying parts of the data it has not been included in this paper.

Table 10: Gathered cost data for deluxe provision

	Zimbabwe	South Africa	
Item	SOS Primary	Bishops College	Micha-Kgasi High School
Summary of data gathered			
Housing: refurbishment, fittings and furniture	$7,441	$2,250	$3,297
Equipment: hardware and software	$33,940	$898,880	$32,592
Annual training cost	$250	$5,833	$9,287
Annual running cost	$2,926	$23,133	$3,004
Annual external support cost	$2,700	$6,186	$258
Number of computers	29	470	21

One of the difficulties in this study is maintaining a consistency in the comparisons being made. This is especially difficult in this section. The provision at *Bishops college* is in an entirely different league from all other provision described in this paper. As a consequence the framework developed for capturing and analysing the cost data was not the most appropriate for *Bishops*. In order to try to capture the full cost of their provision estimates of some of their equipment costs from staff at *Western Cape Schools Network* are also included (see Appendix 4 for details). These have been checked by *Bishops*.

The *housing costs* for SOS include those of building a purpose built computer lab. For *Micha-Kgasi* these are the standard furnishing and security costs detailed in the United Services Agency contract and include desks, chairs, burglar bars and an alarm system. The housing costs given for *Bishops* are only for computer benches and chairs.

The *equipment costs* at SOS include 15 new Celeron computers and 14 refurbished and upgraded 486 machines (see above). This costs roughly the same as the 20 new Pentium III machines ordered by USA for *Micha-Kgasi*. The equipment costs for *Bishops* include 70 desktop computers housed in two labs and the library, 400 lap-tops (estimated at US$1700 each) and a fibre-optic network estimated at US$83,330. Eight servers at a total estimated cost of US$53,333 have been included.

Training costs for *Micha-Kgasi* are based on the number of teachers who are undertaking collaborative learning projects and have attended the WorLD training courses. Twelve collaborative learning projects have being completed at the school. It is interesting to note that *Bishops* also spends around $6,000 on training for its staff. This figure may not include the large amount of informal training which their Director of Computing undertakes with their staff.

Nearly US$13,000 of *Bishops'* $23,000 *running costs* go into charges for connectivity to the web. Ink, toner, power and routine maintenance account for much of the rest. The running costs for SOS and *Micha-Kgasi* do not include costs of web connectivity as neither of these schools access the web.

Unit cost data

Table 11: Unit cost data for deluxe provision

	Zimbabwe	South Africa	
Item	SOS Primary	Bishops College	Micha-Kgasi High School
Summary of user data			
Number of students in the school	840	650	660
Number of "regular" student users	840	650	30
% of students with regular use of computer	100%	100%	5%
Number of regular users (students, staff & community)	842	800	42
Total number of users (regular and non-regular)	845	800	734
Calculated cost data			
Annual cost of computers in school	$13,284	$205,597	$19,343
Annual cost per regular student user	$15.81	$316.30	$644.47
Annual cost per user	$15.72	$257.00	$26.35
Annual cost per computer	$458	$437	$921
Cost per computer over 5 years	$2,290	$2,187	$4,605
Efficiency of usage calculations			
Possible number of regular students	1450	23500	1050
Actual regular students as % of possible regular students	58%	3%	3%
Possible number of regular users if open 10 hours, 300 days	2175	35250	1575
Actual regular users as % of possible regular users	39%	2%	3%
Hypotheticals			
Annual cost per regular *user* if 80% efficiency usage	$4.89	$4.67	$9.83
Annual cost per regular *student* user if 80% efficiency usage	$7.33	$7.00	$14.74

Note:
1. See appendix 1 for calculations of *"Possible number of regular student users"* and for *"Possible number of regular users if open 10 hours, 300 days"*
2. *"..80% efficiency usage"* is 80% of the possible number of *"regular student users"* or *"regular users*" as calculated in appendix 1

All of these schools ensure that all of their students have some use of this equipment. For *Bishops* and *SOS* all students have "regular" use of the equipment. At *Micha-Kgasi* only 30 students are detailed as having regular use. As a result there are very high costs per regular student user and low "efficiency" percentages. This gives further weight to the need for research into the barriers preventing high usage of computer equipment and how these might be overcome. The figures from *Micha-Kgasi* are of particular concern with some of the staff there also having benefited from WorLD training. If this is the case in a WorLD supported school it could be even worse in other schools where there has been central government financed provision of computer equipment and where no training has been provided. Anecdotal evidence indicates there is a problem in this regard and further research is needed to ascertain the true usage of such equipment. At SOS, all students have regular usage of computers resulting in a low *annual cost per regular user"* of US$15.81. However, this is without connectivity costs. The equipment is only used for 22.5 hours per week. While private, or semi-private, schools may not have the same "obligations" as public schools to ensure the maximum use of scarce resources, they do have the same opportunity to ensure that such equipment benefits the wider community. For example *Bishops* has around 100 people, not otherwise able to access computer equipment, who regularly use the college's equipment.

The *"annual cost per computer"* is relatively low for *SOS* and *Bishops*, a part of the reason for this is that the fixed costs are spread over a larger number of computers. *Micha-Kgasi's "annual costs per computer"* are also higher due the higher training costs spread over a smaller number of computers.

For the sake of comparability the equipment at *Bishops* has been amortised over five years. However, *Bishops* intends to replace equipment every three years. This means their actual figures are $692 (instead of $437) for the *"annual cost per computer"* and $500 (instead of $316) for the *"cost per regular user"*.

The efficiency and usage figures are of little relevance to *SOS* and *Bishops*. At *Bishops* much of the curriculum is aided by computer usage and so there is a much higher usage by less students. The figures for hypothetical usage should be treated in a similar way.

Cost comparators and ratios

Table 12: Cost comparators and ratios for deluxe provision

	Zimbabwe	**South Africa**	
Item	SOS	Bishops	Micha-Kgasi
	Primary	College	High School
Ratios			
Cost per computer over 5 years	$2,290	$2,187	$4,605
Cost of a computer	$842	$916	$1193
Cost per computer over 5 years / cost of a computer	2.7	2.4	3.9

Data on cost comparators was not supplied and is of less relevance to *SOS* and *Bishops*. Schools that already have most of the resources they need do not have to consider the opportunity cost of computer provision in the same way as schools with few resources. However, such decisions do have to be made for state schools, unfortunately the information needed to do this for *Micha-Kgasi* was not available.

The ratio of the *"cost per computer over five years"* to the *"cost of a computer"* is interesting. The lower ratio of around 2.5 for *SOS* and *Bishops* does in part reflect the fact that planning, development and to some extent training and support costs, have not been included in the way that they have with basic plus provision and with the figures used in Bakia's work. Such costs are likely to be hidden in other parts of the school's or college's budget. It may also indicate that less back-up and additional resources are needed in this context. The ratio at *Micha-Kgasi* of 3.9 is also lower than that derived from Bakia'a figures. However, planning and administrative costs are not included in these figures. If the overheads of the WorLD programme are included this ratio would rise from 3.9 to 5.1. Such a figure is similar to that derived from Bakai's figures.

Conclusions

From these glimpses into deluxe provision it appears that:

- Private or semi-private schools that are funding the provision of computer resources from their own finances are making good use of these resources in ensuring that all students in their establishment have "regular" use of these resources. In contrast, the government provided resources at *Micha-Kgasi* appear to be under-used.
- The low regular usage at *Micha-Kgasi* gives further weight to the need for research to be conducted into the processes of installing computers in schools which are most likely to bring about high regular usage and into the barriers which prevent high regular usage of existing provision.
- *SOS* shows that it is possible to provide good computing facilities to students at under $20 per year. However, it should be remembered that this figure does not include the costs of web connectivity or of teaching costs. On the other hand at around $700 a year (without teaching costs) *Bishops* shows how much can be spent on high quality web-enhanced learning where most students also have lap-top computers. In a continent where many schools have neither phones nor electricity it also shows the extent of the "digital divide" within Africa.

What is optimal computer usage?

Computers are an expensive educational resource. There are three aspects to increasing the cost effectiveness of their use:

1. Reducing costs: appropriate planning and purchasing can help with this.
2. Improving the way computers are used as an effective educational resource: for this training and research are the key.
3. Increasing the usage of computers. If computer usage increases from two hours a day to ten they can become five times more cost effective.

It is surprising how little importance is attached to the third of these. It is also surprising how many computer labs in schools are only used for just two or three hours a day. In some schools it seems as if the status of having a computer lab is more important than using it properly.

What is optimal usage?

There are two main factors affecting optimal usage

1. Hours of use per day*:* A reasonable standard for a school day is five hours of teaching time. Many schools encourage students to use facilities after school and during lunch times. Some schools also make their facilities available to the community and students from other schools until the early evening. A total of 10 hours per day is attainable for most schools who wish to have good usage of their computers and are prepared to devise a strategy to attain this.

2. Students per computer: Teachers consulted during this research usually felt that three students per computer is too many. For general learning purposes two students per computers seems to work satisfactorily. When students are engaged in individual project work they need a computer each. Wealthier schools tend to provide a computer per student for general ICT teaching and learning. Research is needed as to whether this produces useful educational benefits or whether students working in pairs may be a more satisfactory way of learning.

Appendix 1 shows that with these assumptions each computer should provide for 50 school students to use a computer in pairs for an hour a week and for 30 community users to use a computer by themselves for an hour a week. It is suggested that 80% of this usage be taken as an attainable benchmark.

One of the important findings from this research is that raising usage to optimal levels is likely to be one of the best ways of increasing computer usage and of increasing the cost-effectiveness of computers in education. It is also recommended that research is needed to identify the barriers which prevent optimal usage and how these might be overcome.

Rural Schools

Rural Schools are those without either grid electricity and/or landline telephone connectivity. As such they present a separate set of challenges and cost structures.

If web access and computing facilities are to be made available to children in poor countries the greatest part of this challenge will be rural schools with no access to grid electricity or to landline connectivity. It is claimed that Myeka High School is the first school in Sub-Sahara Africa to have met this challenge and so is described in greater detail. The case study of the *Kgautswane Telecentre* in the section on Community Based Telecentres should also be referred to.

The school

Myeka High School, KwaZulu-Natal, South Africa, (www.myeka.co.za) has neither grid electricity nor landline telephone connection. It does however have 27 computers including a computer lab with 20 computers. These, together with video resources and a photocopier, are powered by a mixture of solar power and an electric generator fuelled by liquid propane gas. The school was connected to the web in early September 2000. To achieve this a mixture of Satellite technology, to send information down to the PC in the school, is used with GSM technology to send information up to the satellite from the PC (also see box entitled "*InfoSat - Connectivity to the web without landlines?"* on page 33). The equipment has been provided by a mixture of companies, NGOs and individuals who are interested both to help the school and to see what can be achieved in such a setting.

In a national programme involving 1,200 schools, *Myeka* was one of three local schools to be donated solar panels. This happened without proper consultation by the donor who simply appeared and installed the equipment over a week-end without prior notification. Unfortunately, these schools had most of these panels stolen or damaged shortly after being installed. This emphasises the need to have strong local leadership and ownership of any such initiative. *Myeka High School* has a dynamic headteacher who has worked closely with the community over 14 years to build up the school. Therefore, they were able to recover the stolen equipment. However, the local police decided they needed to retain the solar panels as evidence of the crime and so the school has not seen these since. As a result of this the replacement systems, which have been donated, run as three separate systems and have not been correctly sized for the loads they power. This means the computers are powered by just one of the systems rather than a combination of all three. Consequently, power is provided from solar sources for a few hours of the day with the gas fuelled generator taking over when solar power is running low.

Careful consideration has been put into the design of the computers to be used. The most cost effective solution would have been to use note-book computers. Although these cost more, the lower power consumption meant less power generating equipment was needed with a reduction in the total cost of about 30% when compared to the desk-top based system which has been installed. There were four main factors which led to installing a desk-top based system:

1. The teachers at the school did not consider note-book computers to be proper computers and said they would not use them.
2. Carrying out basic repairs on note-book computers may not be as easy. Parts and repairs could be more expensive. For Example, if a keyboard needs to be replaced this is a lot more difficult and costly. Furthermore, parts may not be available over as long a period of time.
3. The school felt that note-book computers could be more easily stolen.
4. It was also felt that notebook computers may not be as robust and durable as desk-tops.

The system that is in use involves four sets of monitors and keyboards linking to one CPU. Each user is still able to operate independently of the others. So one CPU is able to service users who are simultaneously using the same or different applications. By doing this each workstation uses 70W instead of 150W. There are two PC cards which can be purchased to achieve this: *Sharedware* cost R2,000 ($294) and *P.C. Buddy* costs R1,800 ($267). With each of these it is recommended that an additional 64MB of RAM per monitor is used i.e. a total of 256MB of RAM for four monitors. At *Myeka* they are experimenting with both systems and with using just 196MB and 128MB of RAM per set of four computers. There is no perceived difference in performance. Ideally a printer is also connected to each set of four computers.

Using this system means there is no server or network to be maintained – something which causes problems in many schools. For a computer lab of 20 workstations software must be loaded onto five computers. This may make it more difficult to protect software from accidental (or deliberate) deletion by users.

Since visiting *Myeka* in August 2000 it has been fully connected to the web. This has caused system conflict problems with the *Sharedware* software. As a result, it was decided to install a Local Area Network (LAN). The cost of this will be about US$3,000 and has been included in this data. It is anticipated that this will give a more stable and robust system as well as giving more control over what is accessible to each user. The *Sharedware* features will still be incorporated into the LAN.

Mangosutho Teknicon (Mantech) will be involved in the running, training and maintenance of the power supply to the site. In doing this they will carry out research into rural electricity supply. Gavin Gradwell who co-ordinates this work is particularly interested in a new technology for electrical generation called the "Dish-Sterling Engine" which concentrates solar energy to run an "external" combustion engine. The engine drives a small generator typically producing 5 to 25 kilowatts of electricity. Sterling engines, together with their solar concentrators, are small enough to be portable to rural sites but are also large enough to make theft difficult, especially when they are embedded in concrete. Furthermore, the Sterling engine can be powered with natural gas or propane so energy can be produced even when the sun is not shining. Mantech is interested in the possibility of using bio-gas to power such an engine – schools which are easily able to harvest large amounts of human waste could be particularly suitable for this. Estimates of the cost of this engine vary. Gavin Gradwell gives figures which indicate a 10KW engine would cost about US$40,000. This is able to run for 40,000 hours (equal to 9 years, running 12 hrs a day) without maintenance. He further indicates that the system is three times as efficient as photo-voltaic panels and capable of generating electricity at costs as low as 4 US cents per KWh. Other people working in this field indicate the that costs are likely to be far in excess of this. The system has been developed by SES an American company based in Phoenix. It is not anticipated to be in commercial production for several years.

The data gathered

Cost data provided from *Myeka* is as follows:

Table 13: Gathered cost data for a rural high school

Item	Myeka High School
Summary of data gathered	
Housing: refurbishment, fittings and furniture	$46,220
Equipment: hardware and software	$45,325
Annual training cost	$40
Annual running cost (including estimated web costs for 15 hrs / month	$4,313
Annual external support cost (guessed)	$2,000
Number of computers	27

Note:
1. The cost of two sets of batteries have been included as equipment is amortised over 12 years and batteries have an approximate life of five years (solar panels have an approximate life of 20 years).
2. $9,000 has been incorporated as the estimated cost of installation. At Myeka this has been donated free of charge. This cost is high at Myeka due to the piloting nature of the work. It should be considerably less at future sites.

Housing costs include US$20,000 for the refurbishment of the classroom as a computer lab and for its furnishing and security measures. Without a detailed breakdown of these costs it is impossible to know why they are so high in comparison to other provision. They also include about US$22,000 for the solar power equipment and about US$1,500 for the back-up generator. One way to reduce these costs is to rely solely on the generator, a solution adopted by the community based telecentre at *Kgautswane* (see page 34).

Equipment costs include US$27,000 for 27 refurbished computers. This includes refurbishment to a specification virtually equivalent to deluxe provision. It further includes the cost of the *Sharedware* system. A figure of US$9,000 is included for installation. This figure may be unduly high due to the experimental nature of this project and it could be that with the lessons learnt from *Myeka* future instillation costs would be greatly reduced. However, as *Myeka* uses 'leading edge technology' the caution sounded by Perraton and Creed in this regard is worth taking note of:

> "*From television to computers a consistent lesson is that education needs to build on the general state of development of technology in the society or community rather than lead it. Educational projects which have been at the leading edge of technology run into difficulties and are rarely sustained in the long-term"* (Perraton and Creed 2000: 76).

"Annual running costs" include an estimate for the cost of web connectivity. As *Myeka* has only just been connected to the web and as these costs are currently being met by the suppliers it is not possible to give accurate costs for connectivity. However, a figure of US$1928 has been inserted to cover 15 hours connectivity a month. This has been calculated on the basis of information provided by infosat (see box entitled *"InfoSat - Connectivity to the web without landlines?"* and Appendix 4 *"Adjustments made to data received"* for further details).

A figure of US$2,000 has also being inserted as an estimate for the cost of annual external support.

Unit cost data

Table 14: Unit cost data for a rural high school

Item	Myeka High School
Summary of user data	
Number of students in the school	850
Number of "regular" student users (this is rising rapidly)	100
% of students with regular use of computer	12%
Number of regular users (students, staff & community)	110
Total number of users (regular and non-regular)	400
Calculated cost data	
Annual cost of computers in school	$19,270
Annual cost per regular student user	$192.70
Annual cost per user	$48.17
Annual cost per computer	$714
Cost per computer over 5 years	$3,568
Efficiency of usage calculations	
Possible number of regular students	1350
Actual regular students as % of possible regular students	7%
Possible number of regular users if open 10 hours, 300 days	2025
Actual regular users as % of possible regular users	5%
Hypotheticals	
Annual cost per regular *user* if 80% efficiency usage	$7.61
Annual cost per regular *student* user if 80% efficiency usage	$11.42

Note:
1. See appendix 1 for calculations of *"Possible number of regular student users"* and for *"Possible number of regular users if open 10 hours, 300 days"*
2. *"..80% efficiency usage"* is 80% of the possible number of *"regular student users"* or *"regular users*" as calculated in appendix 1

As the system at *Myeka* has only just become fully functional, usage figures are still relatively low. However, since web connectivity was obtained they have started to rise dramatically. As a result of the current low usage figures, the *"annual cost per regular user"* of US$193 is high when compared to basic plus costs of around US$96 at *Ngaka Maseko* and US$19 – $32 in Zimbabwe. However, if all 850 students at *Myeka* became regular users, this cost could fall to around US$23 per student. This figure is comparable to that of the WorLD provision in Zimbabwe but it could be that considerable training costs would be incurred in order for it to be achieved. This is a further indicator that increased usage is the best way to reduce unit costs.

Interestingly, the *"annual cost per computer"* is comparatively low at US$714 compared to $955 at *Ngaka Maseko* (South Africa) and between $1,200 and $1,600 in Zimbabwe. This is mainly due to the higher fixed costs being spread over a much larger number of computers than is the case with WorLD provision.

The calculations for *hypotheticals* indicate that with usage at this benchmark level it could be possible to enable students to have regular computer usage in rural areas at about US$12 per year. However this figure should be treated with caution in a rural area for several reasons.

1. There are only 850 students in the school. For a figure of about $12, students from other schools would need to use the facilities. In rural areas schools are more spread out making this difficult and often impossible. Primary school students could be given access but in some countries the need to use English language would be a substantial barrier.
2. In order to obtain such levels of usage it is likely that much higher training costs would be incurred. This is especially the case if such use is to be integrated into the curriculum. Clearly, costs would increase with more training.
3. If there is higher usage, with greater curriculum integration, then web usage is likely to be much higher. At $7.80 an hour this can easily add a considerable amount to running costs.
4. Higher usage would also add considerable amounts to the fuel costs of a back-up generator which would be needed for extended usage.

Clearly, there is a difficulty here. Higher usage means a more efficient use of a scarce resource, an indicator of this is lower unit costs per student user. Yet higher usage also raises the running costs faced by a school. It could be the case that schools such as *Myeka* simply could not afford the running costs of high usage and so would discourage it. User fees may be a part of the answer, this research indicates that parents are willing and able to meet some of these costs. However the case study at *Yomela* (see basic section) indicates that such fees are a considerable barrier which also prevents high usage as poorer parents simply cannot afford these fees.

Cost comparators and ratios

Table 15: Comparators and ratios for a rural school

Item	Myeka High School
Cost comparators	
Cost of a Grade 9 text book (guessed)	$10.00
No of text books for annual cost of computer provision	1927
Ratios	
Cost per computer over 5 years	$3,568
Cost of a computer	$1000
Cost per computer over 5 years / cost of a computer	3.6

Unfortunately, data to make a comparison of the alternative uses of the resources used for computer provision was not provided. If a figure of $10 is taken as the cost of a text book then around 1,900 text books could be purchased for the school, each year, for five years. However, as has previously been mentioned these resources may not be available for alternative uses. In the case of *Myeka* many of these costs have been met by the local community and business people who are interested to see if this technology can work and if its use can improve educational outcomes in a rural environment. It is unlikely that such resources would also be available to purchase other educational inputs. If schools are able to enter into partnerships with local businesses and community groups they are more likely to be able to access and maintain computer resources.

A cost comparison of a different nature can also be made. In December 2000, solar panels became operational on the latest space station to orbit the world. The cost of this was US$600,000 million (BBC World, 9th December 2000). If we take the above cost of $3,568 of providing a computer for five years to a rural school, then such a sum invested in solar powered computer education in rural areas in developing countries could provide 168 million computers for five years. If 50 school children use each computer in pairs for an hour a week then 8,400 million children could benefit from such education. If we assume just 1,000 million children in the world then each child could, on these assumptions, have around four hours of individual computer time a week. The challenge facing the world's leaders who proclaim a wish to "bridge the digital divide" may simply be to commit resources to such an initiative which are equivalent to the resources committed to providing solar power for experimentation in space.

The ratio of 3.6 for the *"cost of a computer"* to the *"cost per computer over 5 years"* is of a similar magnitude to the ratio derived from Bakia's figures and similar to the 3.9 at *Micha-Kgasi* where similar provision has been installed. If substantial training costs were to be incurred then this ratio would become closer to the others cited.

Conclusions

From this brief glimpse into provision in rural areas without either grid electricity or landline telephones it appears that:

- Obtaining high usage is again the key to low unit costs but that in rural areas there may be greater barriers to high usage relating to the additional costs of connectivity and fuel and the distance that may have to be travelled for users from other schools.
- While computer provision is possible in such circumstances it is necessary to employ "leading edge" technology in order to achieve this. This raises questions about its robustness and sustainability. However, change is rapid in this area and such pilot projects should be carefully monitored and evaluated so that the lessons which can be learnt from them are available if/when such technology is more common and accessible.

- Careful measurement of the power consumption of different computers and different configurations would aid the planning and design of non-grid-based provision.
- With careful planning and management to ensure high usage, the costs of computer provision in rural areas need not be substantially greater than for schools with grid electricity and landline phones. This is especially the case if full connectivity is not provided but data casting or CD ROMs are used as an interim.

InfoSat - connectivity to the web without landlines?

InfoSat is a way of connecting to the web. There are two parts to web connectivity:

1. Incoming to a PC: receiving information from the web.
2. Outgoing from a PC: i.e. sending or requesting information.

InfoSat performs the first of these functions, with information being transmitted down from a satellite to a receiving dish and into a PC. For full web connectivity a telephone connection is needed to perform the second of these functions i.e. to send a signal up to the satellite to tell the satellite which web pages to transmit down. In rural areas where there is no landline connectivity such a connection can be made through a GSM system. When this is combined with solar power it means that schools without telephones or mains electricity can be connected to the web.

The costs of such a system in South Africa are as follows:

1. For receiving information into the PC

a) Full connectivity. InfoSat will charge schools R299 (US$44) per month for unlimited connectivity to the web for a single computer or R3,500 (US$515) for a network of 15 computers. This price includes the hardware that is needed – a card for the PC and a satellite dish.

b) Data-casting. A lower cost option allows schools to receive pre-determined web pages which are updated daily. The selection of web pages can be changed on a weekly basis. A school could have all of The Learning Channel, the BBC and Discovery Channel web-sites downloaded to its server each day. Students could then surf this "mini-web" on a school network. The number of web pages cast down is only limited by the capacity of the receiving computer / server. InfoSat believe that commercial companies who have purchased bandwidth and have slack times e.g. between 2 a.m. and 6.a.m. would allow this to be used free of charge for data-casting to schools. To receive such a service a school would only need to meet the initial fixed charge of the following hardware:

PC Card: R2,000 (US$294) Satellite dish: R1,000 (US$147)

Besides not giving full web connectivity, the other disadvantage of the data casting option is that email is not possible. Many students and teachers greatly value the email facilities, the absence of this also prevents collaborative learning projects. However, the very low running costs could make this an attractive option to enhance learning facilities in many schools and might be a useful interim step until full web connectivity is affordable.

2. *For outgoing signal from the PC*

This is needed for full web connectivity. There are two parts to these costs:

a) Capital costs

GSM Aerial: R200 (US$30), GSM modem: R1600 (US$235)

b) Recurrent costs

Phone calls to send data out cost R0.90c (US$0.13) per minute. It is necessary to be connected to the phone all the time that data is being received from the satellite, however this time is less than for land-line connectivity as data is received at a much faster rate. This cost is equal to $7.80 per hour or $1,400 per year for 15 hours use per month.

If 400-500 schools used this service it might be possible to negotiate reduced costs of about R0.65c (US$0.10) per minute.

Coverage

InfoSat currently covers South Africa, Botswana, Namibia, Zimbabwe, Mozambique and the southern halves of Zambia and Malawi by its Ku band. On this band the receiving dishes are 0.6 – 1.5 m in diameter and cost R800 – R1,500 (US$120 – 200), including installation. For the rest of Africa, InfoSat could provide coverage on C band. The difference being that dishes on C band are 1.8 – 3 m in diameter and cost R2-5,000 (US$300 - $735) plus instillation.

Community based telecentre provision

Community based provision often uses a telecentre model and serves several different users which might include schools as well as the local community. Typically, usage is over more hours per week than single school provision.

Community based provision provides access to, and training in, the use of ICT to different groups and members of the community. The following case studies look at two telecentres in South Africa which are not school centred but which are used by the local community, including teachers and school students. Unfortunately cost data was not provided for these centres. In addition to this, the provision being established by the government of South Africa through the USA is briefly described with more details, including some of the initial costs, being given in appendix 3.

Kgautswane telecentre is described in greater length as it is rural based and gives useful insights into the process involved in establishing this type of provision. Many of these insights have general applicability.

The centres

Chiawelo digital village, Soweto, South Africa, was established by Africare, a Washington D.C. based NGO, as one of its four digital villages in South Africa. These telecentres have a variety of users and the one at Chiawelo is housed in a community centre. Usage is split evenly between access and training. Demand for training is particularly high. The village is open from 8.30 a.m. – 7.00 p.m. and operates on a business model to enable it to be financially self-sustaining. Users pay R480 (US$72) to become a member for a year. Alternatively, they can pay R460 (US$68) for a three month course with three months access following this. These fees enable the centre to meet its running costs. The digital village currently has a membership of 407. In addition to this, about 800 people attend training courses each year. There are 34 workstations in the digital village. Courses are run for 34 people at a time with one instructor and 1-2 helpers per class. The majority of users are young adults aged 20-35 who feel they need computer skills to get jobs. When the village was visited most of the users were unemployed people in their 20s.

Kgautswane telecentre, Northern Province, South Africa, *(not visited),* is in a remote part of the country without grid electricity but with a telephone line. There is a population of 70,000 people and there are three schools. The World Bank funded the initial costs of the centre as a pilot project. They are especially keen to see who uses the facilities and the impact this has in the area.

The centre has four computers, a server, a fax, a copier, scanner and one phone line. Power is provided from a petrol generator which costs R3,000 (US$500) and has a life of about 6 months.

The cost to the World Bank of establishing the centre has been US$50,000, this has been spent on:

- Equipment
- Installation
- Furniture – including steel cages for the computers to prevent theft
- Training

About 40% of costs were associated with training. This included local teachers, community leaders and the centre manager. In addition, twelve months of service back-up and maintenance were provided. This was considered essential for the people operating the centre to become confident and competent to run and maintain it. Initial usage of the centre was very heavy. It has now settled at around six hours a day. Charges are made which cover all running costs, including the salary of the centre manager and the replacement of the generator every six months.

The success of the initiative relates not just to putting equipment into the centre, but also to the processes utilised. Critical to this is leadership and ownership.

There are three stages involved:

1. *Developing leadership:* it is especially important that all sections of the community are included with links to local chiefs, etc. Women's groups are also important. In many rural areas in South Africa, women run communities, especially during the week when many men work in urban areas.
2. *Test the leadership:* to see if it can mobilise resources effectively.
3. *Support the leadership:* so that structures are strengthened and it becomes more effective.

Ownership is also critically important. The community at *Kgautswane* was identified as suitable for this facility largely because they wanted it. If the community does not see the facility as belonging to them, then it is unlikely to work and will almost inevitably be pilfered or not maintained. If equipment is simply put into communities without the processes of developing leadership and ownership and giving subsequent support, then it will not last. Only 6% of the government centres established by the Department of Communication still had phone lines one year after installation and none of them retained the computers which were installed.

Interestingly, it was also made clear to the community that if the equipment was not used then it would be packed up and moved elsewhere.

Ross Paul of the World Bank, who was involved in this project also believes the same processes need to be followed when putting computer equipment in schools. Ideally teachers, students and the community need to be involved, along with the headteacher and management board.

Unfortunately it has not been possible to gather cost data on this project.

Government provided telecentre Universal Services Agency (USA), South Africa (see the case study on *Micha-Kgasi* in the deluxe category on page 22.) is in the process of establishing ten telecentres which will be based at or close to Post Offices. Six networked computers will be installed with a printer, fax, photocopier, scanner, air conditioning and security measures. The telecentres will be run by non-profit organisations. The postal part, while in close proximity, will continue to be run separately as a private enterprise.

Further information on equipment and costs is contained in appendix 3.

Commercial Provision

Commercial provision is when training and access are provided by the private sector on a break-even or for-profit basis.

In most major streets in main cities in developing countries there are signs or adverts for computer training. Unfortunately, time did not permit investigation into this provision. However, a brief visit was made to NIIT in Zimbabwe. In addition to this, the plans for IT2kids, a commercial enterprise aimed at bringing computing to primary school students in high density areas in Zimbabwe is also described.

NIIT Zimbabwe, is a franchised operation of NIIT India where it is a very large computer software and training company. In Zimbabwe they offer an initial course in MS Office 97. Following this there are courses in various computer programming languages (e.g., Unix, visual basic, Java, etc.). There are also self-study kits available on the different courses. A new course in e-commerce will soon be launched. Unfortunately, it was not possible to clarify the cost data supplied by *NIIT* in Zimbabwe to a sufficient extent for inclusion in this paper.

IT2kids, Harare, Zimbabwe, is the vision of Tafara Gwata and Ramadhani Hayeshi both of whom have worked in the commercial part of the IT sector for a number of years. Between them they have a considerable track record in the design, installation and servicing of a number of large and small computer networks. Their ambition is to make ICT affordable and accessible to children in high density and rural areas of Zimbabwe. Their plan involves using four trailers, each equipped with ten computers. These are towed by one truck. Each morning a trailer is dropped off at a school and picked up again at the end of the day. Each school would have a trailer of computers twice a week.

The lessons using the computers will be taught by the school's teachers who would be given a week's course on ICT skills, teaching ICT and its use in the curriculum. This training would be provided by *IT2kids'* training instructor who would also provide ongoing support and advice to the teachers as they become confident in using and teaching with ICT. Lessons would last an hour each and students would have two lessons a week. Access to the web could be given at schools where there is a phone line.

The model enables 140 students per school, per week to have ICT lessons for two hours a week. This means that the four trailers would enable 1,400 students a week to access these lessons. If students have these lessons for a term, then four trailers enable 4,200 to have such access in a school year. Additional access can also be given in the holidays. It is envisaged that the trailers would be used at community centres etc. at week-ends.

The provision would involve a server and workstations as thin clients, with mobile LAN networking infrastructure. Computers and software would be replaced every three years.

IT2kids calculate they can supply this provision on a commercial basis of Z$100 per student per month (= US$2 per month / US$24 p.a.). If two sets of trailers are used economies of scale might be obtained to bring this down to $Z64 per student per month (= US$1.30 per month / US$15.60 p.a.). This figure includes all training and running costs, rental of a base and amortisation of equipment. It does not include phone charges to an ISP which would have to be met by the school. *IT2kids* is seeking loan facilities of Z$4m (=US$80,000) for a four trailer set.

They hope initially to operate with one and then two sets of four trailers as a pilot project. If this is successful they would seek to scale up the operation.

This is an interesting model as it is operated by the private sector. As such they have an incentive to make it work and to maximise the use of the computers.

Connectivity options – a dummy's guide

There is a bewildering range of choices and amounts of money that can be paid to get connected to the web. Here are some of the options:

Dial-up**:** is where you simply plug your modem into the normal telephone line. Speeds are usually up to 56Kbs. Costs are the costs of the phone call plus any fees that the Internet Service Provider (ISP) charges.

Leased Line: is a high speed link via the national telephone system. Special hardware is needed such as routers. This is an expensive option currently beyond the reach of most schools.

ISDN: is a dial up system but is much faster at 128Kbs. In South Africa (RSA) you pay an initial installation charge plus a fee of R175 ($26) per month for two lines. Call charges are paid in the same way as dial-up connections but should be less due the quicker speed of data transfer (in RSA R0.24c = US$0.35c per minute).

DSL (Digital Subscriber Line): is a fast way of connecting to the local exchange – a speed of about 2 Mbs. In RSA it is being experimented with and may costs around R500 (US$ 74) per month.

Wireless: can be via terrestrial or satellite links and bypasses the local fixed line telecommunications infrastructure. Connectivity rates can reach as high as 2Mbs. For terrestrial connectivity a spread spectrum microwave technology is used and there must be a direct line of sight to the nearest antennae (usually a distance of around 20km). Satellite connectivity can take many forms from receive only to send and receive. VSAT (Very Small Aperture Terminals) are increasingly being deployed in rural areas**.** In RSA the dish alone costs R30,000+ (US$4,410+) and the recurrent costs can get as low as US$50/month with a large enough number of users in the network.

6. Other factors

Anecdotal evidence is mounting to indicate that simply putting a computer lab into a school with the appropriate hardware and software does not bring about effective computer provision. When this occurs labs are more likely to be left locked and unused. When use does occur it is usually on an ad hoc basis as individual teachers see fit and is rarely integrated into the curriculum. Often repairs are not carried out for long periods of time, if at all, as schools see the responsibility for maintenance as being that of the supplier of the equipment whether this is the government or an NGO.

While not being the main focus of this research, it is apparent that in order to bring about effective computer usage in education several other factors should be considered:

- The processes of provision
- The training of teachers
- Models of provision: Telecentres and school based-labs

Processes

When computers are given to (or "imposed on"?) schools without proper consultation their usage and maintenance is less likely to be thought through. Generally, when something is given by a central bureaucracy it is valued less and is more likely to be resented and treated as a burden. This is not always the case and outcomes vary from country to country and from school to school. In some situations teachers are so delighted to have a new resource and are keen to use it irrespective of how it has reached them. However, processes of provision which foster local leadership and ownership of resources are more likely to facilitate their effective use. The case study of the *Kgautswane telecentre* (see page 34.) gives useful insights into the importance of this aspect.

While each country has to determine the processes which will work best in the context of its history and culture there may be some useful lessons to be learnt from the process employed in Chile (see Alveriz et al 1998). Some of the main elements of this and other programmes which can help to bring about effective provision in the right circumstance are as follows:

- Schools can bid for the provision of computer labs on a competitive basis. This has the advantage that they have to do something to obtain provision. If successful, they feel they have earned it and it belongs to them.
- In making their bid, schools can outline how they will ensure the computers are used effectively, should their bids be successful. This means that schools think these processes through for themselves. If they do this they are then more likely to take the measures needed to ensure effective provision.
- In making their bids schools can be asked to cover key issues which experience shows are important for effective provision. Examples could include:
    - How computer usage will be integrated into the curriculum and how this will be timetabled?
    - How the headteacher, senior staff and a certain percentage of all other staff will access training in the use of computers?
    - Will the computers be available for use by the local community? If so, what will be the arrangements for this and how will this use be promoted?
    - How will running and maintenance costs be met?
    - Who will manage and maintain the provision?

It is important that this process is not too burdensome. One set of proposed criteria for such an exercise required answers to over 40 difficult questions. Few, if any, headteachers and their governing bodies have the time to engage in such a process. A maximum of six criteria should be adequate.

Obviously there are losers in each round of bidding. However, all programmes of large scale computer provision happen in a phased manner with some schools gaining provision before others. With this model, successive rounds of bids can be run with the same net result but with provision first going to schools most likely to make best use of resources. Schools less likely to fully utilise resources can be given additional help in thinking through critical issues and can learn from schools that make successful bids. One criteria of the bidding process could be that bidders outline how, if successful, they would act as "beacon schools" and would help other schools with the thinking and preparation of their bids.

One danger of this model is that the best and most capable schools gain all the resources. Schools where staff have little idea of computers and the way they can be used in education have little chance of preparing winning bids and so gaining these resources. Where this is the case extra support needs to be available to such schools to work through important issues and prepare effective bids.

Training

Provision of training for staff in the use of computers is often a critical factor in their successful utilisation. Training is an input, which has to be costed into plans. Perraton and Creed note that "Recent experience in the North suggests that effective computer-education projects, for example, demand as great an expenditure on training and software as on hardware" (Perraton and Creed 2000: 77). It is also part of the processes involved in effective computer provision. Yet it is often neglected. At *Kgautswane* (see case study on page 34.) 40% of the budget was spent on training. In many ways expecting schools to utilise ICT for education purposes without any training is akin to giving an executive jet to a company and expecting them to utilise it without any training in flying. It is surprising how many educational planners seem to neglect the training and educational needs of teachers!

The timing of such training is also critical. If it is provided before equipment is available then practice, which is an essential part of skill acquisition, is often impossible and so skills are soon lost. If it is provided too long after the provision of equipment then valuable resources are idle for too long and the incentive for learning which new provision can bring soon diminishes. "Just in time, not just in case" seems an appropriate motto.

It has not been possible to undertake a detailed survey of the costs involved in training provision. However examples of such costs incurred by WorLD are given in table 16.

Table 16: An example of training costs as incurred by WorLD

WorLD training costs		Course Duration	Number of Participants	Total cost US$	Unit cost US$	Type
Jan 26 -30 1998	Uganda	5 days	18	$7,688.00	$427.11	International
Feb 1-6 1999	Uganda	5 days	22	$6,289.00	$285.86	International
Oct 13 - 17 1997	Ghana	5 days	15			
Oct 20 - 24 1997	Ghana	5 days	25			
			40	$12,052.00	$301.30	International
Nov / Dec? 1998	RSA – KZN		29	$11,185.00	$385.69	Local
Jun-98	RSA – NW		27	$11,411.00	$422.63	Local
Oct-98	RSA – EC		27	$12,738.00	$471.78	Local
TOTAL			163	$61,363.00		
Average unit cost per training course					**$376.46**	

These costs are marginal costs. They give the additional cost to the WorLD programme of mounting particular training courses. They do not give the total costs which would include the costs of developing training courses and materials and an apportionment of the running costs of WorLD.

Models of provision: some thoughts on telecentres.

During the course of this research two main models of school based provision were encountered. On the one hand there is school-based computer lab provision where there is a lab in a school which is run and financed by the school. On the other hand there is the school-focused telecentre model as operated by WorLD in Zimbabwe (see section on Basic Plus provision). Insufficient data was gathered during the course of this research to be able to make a meaningful comparison of these two types of provision. However, from the data gathered and the impressions formed from the visits made during the course of this research the following should be noted.

- The school-focused telecentre model as operated in Zimbabwe tends to have high student usage with the facilities being used for a greater number of hours.

- In the case of the model operating in Zimbabwe consideration should be given to increasing the number of computers per telecentre. If 20 computers were provided instead of 10, the marginal cost of the extra provision would be very small (about $6,000 out of a total cost of about $75,000 over five years). In doing this unit costs would be nearly halved so long as usage levels are maintained. As the telecentres in Zimbabwe also have two dedicated staff for each centre (not included in these cost figures) it would also be a much better use of the expertise of these teachers. As many teachers teach ICT classes of 30 or more students, it should be possible for two teachers to effectively teach and tutor up to 40 students at 20 machines. While it may be tempting to increase the number of telecentres rather than to increase the number of computers per centre, the former is a far more costly and so a less cost-effective option. Increasing the number of computers per lab is likely to ensure that a much greater number of students have training in, and access to computing, even if these students are geographically more concentrated. Figures from Zimbabwe indicate that the centres currently only provide for 7-16% of their schools populations.
- Evidence from *Bindora* indicates that non-school based telecentres may be able to facilitate more out of school usage by non-school students. For instance students from the Zimbabwe Open University regularly use the *Bindora* centre at the week-end.
- In the Zimbabwe telecentres, the two teachers tend to work simultaneously with both of them present at the same time. If the day was divided into three sessions: morning, afternoon and evening with teachers doing one session by themselves and another simultaneously, then this could facilitate greater usage of the centres. If the telecentre model is adopted in other countries then this adaptation should also be considered to facilitate greater usage. Similar arrangements also need to be thought out for holiday periods.
- Countries adopting a telecentre model should also consider issues relating to teachers conditions of service. In many countries teachers have 12-14 weeks holiday a year. This is too long a time for a facility that can be used by the community, to be unavailable for its use. In Zimbabwe, the teachers running the telecentres still retain their teachers conditions of service. In practice, many of them work during a part of their holiday on a voluntary basis. However, policy makers should bear in mind that teachers tend to have longer holidays than other employees because of the very long hours they work outside of school on marking and lesson preparation. In many countries, teachers employed in educational posts which do not require large amounts of marking and preparation accept that their holiday entitlement will be reduced to the norms of that country. In the Zimbabwe telecentres, teachers do not have large amounts of marking and assessment work and do not prepare new lessons for each day. A careful re-negotiation of conditions of service in such situations may be needed in some countries to ensure an optimal use of scarce computing resources in a cost-effective manner.

Computer technology in the future?

It is difficult enough to plan and budget for technology in schools today let alone try to anticipate what the future will look like. However, technology co-ordinators must think about a couple of trends that are important to keep in mind as they plan their networks.

Unwire your schools. Wireless technologies present a great opportunity for schools to connect both local area networks (LANs) and wide area networks (WANs) at a much lower cost than existing wired technologies. Wireless LANs save older schools and schools with a number of buildings dispersed across a campus the need to lay spools of Ethernet cable. Wireless LANs also provide the teacher with greater mobility to bring the lab to the classroom as opposed to bringing the class to the computer lab.

WANs with wireless connections to the Internet also allow schools to bypass the local telephone network and connect directly to an Internet Service Provider (ISP). This direct connection allows schools to avoid the local per minute rates charged by local telephone companies and budget their connectivity costs based on a fixed monthly rate. Also, the wireless connections – either through spread spectrum microwave technology, satellite technologies such as VSATs or new "third generation" technologies allow for greater bandwidth than a dial-up modem connection. For instance, in Uganda the schools involved in the World Links program moved from a fixed line dial-up connection in which their monthly bills were around US$250/month with a throughput connection rate of around 14.4 kilobits per second (kps). At this monthly cost, schools were only able to connect for around an hour per day. Moving to a wireless spread spectrum connection, the schools were able to increase throughput to around 256 kps, pay a monthly fee of around US$200/month, and have a permanent connection to the Internet for 24 hours a day. With VSAT technologies, recurrent costs for 512kps access could be reduced to as little as US$50/month if a large enough number of schools were to participate in the network.

Rethink the "computer". In the next 5 years, we will see a proliferation of computer "devices" that students and teachers will use in their classrooms for word processing, data spreadsheets, stand alone software programs, and access to the Internet. While we have seen a progression from 286 machines to 386, 486 and now Pentium III machines with 700mhz processing power and Gigabyte hard drives, the future will bring an array of handheld, portable, solid state devices that will provide much of the same functionality of traditional computers at a fraction of the cost. Existing devices include palm pilots, thin clients, simple word processing machines, and e-book portable reading machines. Future machines may be as cheap as a radio and as simple to use. Some predict that the costs could be as low at US$50 in the coming years. It is also important to consider use of refurbished 386, 486, and low-end Pentium computers for schools. With appropriate software, these computers can accomplish the simple word processing, data processing, and Internet access functionality that students and teachers need without spending the money for the latest and fastest personal computer.

Bob Hawkins, Manager WorLD, April 2001

7. Conclusions

From the analysis of data in this study we can conclude the following:

1. Usage, efficiency and unit costs

A consistent finding throughout this research is that the best way to lower the unit costs, i.e., the cost per student, is likely to be achieved by increasing the usage of the equipment provided. Research is needed to determine the actual levels of usage in schools. If, as suspected these are a low percentage of what is possible, then research also needs to be conducted concerning the factors which prevent higher usage and how these might be overcome.

Situations where expensive equipment is supplied to schools and receives only a fraction of the usage that is possible during the school day, need to be investigated and lessons learnt in order to avoid such situations. However, even when computers are fully used during a school day this will often only amount to five of six hours usage a day for five days of the week and for under 40 weeks of the year. Schools are rarely good at encouraging community usage of their facilities and for understandable reasons. However, in addition to the increased efficiency, and the corresponding reduction in unit costs that can occur when computers are used for 10 –12 hours a day, this additional usage gives schools the opportunity to facilitate and develop good school / community relationships. Good school /community relationships are one of the factors which research shows can improve educational outcomes. Programmes, worked out with local community leaders, to give high levels of access to computing facilities in schools offer the opportunity to engage in an activity which makes a more efficient use of facilities, builds school / community relationships and, as a result, can improve educational outcomes in other ways.

2. Hardware and software provision are only a part of the costs of total provision

Analysis carried out in this research indicates that the cost of providing hardware and software is only a part of the total cost of provision over a five year period. Analysis of the figures produced by Bakia for three middle income countries indicates that the total cost of provision over a five year period, is likely to be between five and six times the cost of providing new equipment (hardware and software costs). In the small sample of deluxe schools looked at in this research, the total cost of provision over five years appears to be between two and a half and five times the cost of equipment. One reason for the lower figure could be that planning and central support costs included in Bakia's work do not appear in single school based provision as they are absorbed by other parts of the school budget. Where second–hand equipment is used in basic and basic plus provision the total cost over five years is likely to be between twenty and thirty times the cost of equipment. This is because the cost of refurbished equipment is lower – often around a quarter of new equipment and because, in the case of basic plus provision, as provided by WorLD, there is considerable training and support provided which has a significant cost.

It should also be pointed out that the total cost figures included in these calculations do not include teachers salaries. If these were to be included the ratios would be considerably higher.

3. Rural provision need not be a lot more expensive

Figures from *Myeka* indicate that if all students in the school use the computers on a regular basis then provision can be supplied at under $20 per student per year. This figure included an exceptionally high figure for classroom refurbishment and high initial instillation costs and so might in practice be considerably less. If full connectivity is not needed and a data-casting option or CD ROMs are used then costs can again be reduced.

4. Schools will need help with cost recovery

When computers are provided in many schools, cost recovery measures are often encouraged as a way to meet running costs or, in some cases, total costs. During this research when schools were asked about this they frequently replied that this was something they intended to do but had not yet started.

If schools are to provide a service, out of schools hours, which they charge for and operate as an income generating venture, it is likely that they will need help in planning and executing this. Undertaking such a venture is akin to running a small business. Few teachers have a background in entreprenuership and business development and state schools rarely operate as businesses. Evidence from agriculture and vocational education indicates that school's "income generating" activities can too easily become "loss making" activities. Where schools are expected to generate income from out of school computer usage then help is likely to be needed in marketing, costing, pricing, general business planning and management. Many countries have NGOs operating in the field of small enterprise development who might be well placed to offer such training and support.

5. Variety of provision and costs

During the course of this research it has become apparent that there is a large variety of computer provision both between different countries and within different countries. The provision of computer labs with new state of the art equipment previously explored by Osin (1998) and Bakia (2000) tends to be the option pursued by relatively wealthy middle income countries or relatively wealthy sections of poor countries. Poorer countries and communities tend to pursue options involving second hand and refurbished computers. Often these are provided from Europe or North America, sometimes with some technical and pedagogic support. In this research three main cost categories have been identified for school based provision:

- *Basic,* using second hand-computers.
- *Basic plus,* using second-hand / refurbished computers but with technical and pedagogic support.
- *Deluxe,* using new equipment.

In addition to this rural schools present a separate set of challenges and cost structures.

6. Benchmarks and ratios

Appropriate benchmarks and ratios need to be developed in order to assist planning of computer provision and assess the efficiency of usage once computers have been provided. From this research four are suggested:

- Two benchmarks for efficiency based on usage as a percentage of reasonable possible usage. First, a benchmark for *"actual regular students as a % of possible regular students"* with a figure of 50 students per week using a computer for one hour a week in pairs being regarded as a likely maximum. Second, a benchmark which includes wider community usage of *"actual regular users as a % of possible regular users"* an additional 30 students should be able to use a computer for an hour a week during out of school time to give a possible maximum of 80 students. It is also suggested that schools should be able to perform at 80% or above of this benchmark. Where schools are able to provide single usage for students then this benchmark needs to be adjusted. However, it could be the case that learning in pairs, besides being more cost effective, could also be more educationally beneficial. This is also an area that needs further research.
- A benchmark of *"the annual cost per regular student user"* combines efficiency of usage with costs. Benchmark figures derived from this with vary with the type of equipment purchased for different categories of provision.
- A ratio for *"the cost of a computer to the total cost of effective provision over a five year period"*. Clearly, such a ratio will be different depending on the type of provision. This research indicates that for new equipment the ratio is likely to be between 3.5 and 6 and for second-hand refurbished equipment between 20 and 30. However, no research has been conducted to indicate whether or not this will secure effective computer provision and education. Clearly many other variables will also affect this.

7. A Telecentre model may be more efficient

While the data gathered during this research is not sufficient from which to draw firm conclusions, there are indications that a school-focused telecentre model will ensure that computing facilities are used for longer hours than provision through a school based computer lab. This in turn leads to a more cost-effective use of resources.

The data on which these conclusions are based is summarised in the following table:

Table 17: Summary of data presented

	Basic			**Basic plus**			
	Harare	Mutoko	Yomela	High Glen	Marondera	Bindora	N. Maeseko
	High	High	Primary	Telcentre	Telecentre	Telecentre	High
	Zim	Zim	RSA	Zim	Zim	Zim	RSA
Cost per computer over 5 years	$1,794	$2,414	$972	$7,297	$5,932	$7,913	$4,776
Cost of a computer		$28	$48	$250	$250	$250	$210
Annual cost per regular student user	$31.47	$13.05	$9.72	$365.00	$19.30	$31.65	$95.52
Annual cost per regular *student* user if 80% efficiency usage	$3.83	$5.15	$2.07	$23.35	$18.98	$25.37	$15.28
Actual regular students as % of possible regular students	23%	74%	40%	24%	94%	111%	15%
Notes				2,1	1	1	1

	Deluxe			**Rural**	**Central Govt.** (Bakia 2000)		
	SOS	Bishops	Micha-Kgasi	Myeka	Barbados	Turkey	Egypt
	Primary	College	High	Rural High			
	Zim	RSA	Zim	RSA			
Cost per computer over 5 yrs.	$2,290	$2,187	$4,605	$3,568	$9,690	$6,400	$10,238
Cost of a computer	1125/842	$916	$1,193	$1,000	$2,000	$1,100	$1,600
Annual cost per regular student user	$15	$110	$644	193	n/a	n/a	n/a
Annual cost per regular student user if 80% efficiency usage	$4.37	$28.26	$9.83	$7.61	$194	$128	$204
Actual regular students as % of possible regular students	58%	26%	3%	5%	n/a	n/a	n/a
Notes				3	4,5	4,5	5

Notes:

1. Substantial training costs and central management and support costs provided by WorLD are included in these figures.
2. *High Glen* has a different usage model giving high one-off usage but low "regular usage", this results in a high unit cost figure for regular usage.
3. *Myeka* includes very high costs for classroom refurbishment and for initial instillation. These should be reduced in other situations.
4. Central management and support costs included in these figures together with some training.
5. Housing and furniture amortised over 5 years where as it is amortised over 12 years in other cases.

In drawing conclusions from this data it should be borne in mind that the data should be taken as giving costs which are of the right magnitude rather than precisely accurate figures. While considerable effort has been taken to refine and check the accuracy of this data there is a limit to the degree of accuracy that can be obtained. There are several reasons for this, for instance, exchange rates have depreciated in recent years in both of the countries in which data was gathered. This means that for a totally accurate reflection of prices multiple exchange rates should have been used depending on the precise date of each purchase. For South Africa the Rand has gradually depreciated to a rate of $1 = R6.8 in August 2000. However most purchases were made before that date so a rate of $1 = R6.0 has been used to give the value of costs in US$. This means that items purchased some time ago, when the Rand had a higher value, will be undervalued in US$ where as the opposite is the case for very recent purchases. In Zimbabwe, with inflation rates of around 60% this problem is much worse. During this research the Zimbabwe $ was devalued from $1 = Z$38.5 to $1 = Z$50, in 1998 the rate was $1 = Z$16.5. Various parallel rates have operated along side this. In this research an average of $1 = Z$40 has been used. Furthermore, some figures such as electricity costs have often had to be estimated, other data supplied appeared to be inaccurate to such an extent that to include it without making adjustments would have distorted the figures to such an extent as to be misleading. Where adjustments have been made these are detailed in Appendix 4. Furthermore, data gathered for this research has not been discounted. Without knowing precisely when costs have occurred it is difficult to do this, and to do so gives an impression of precise accuracy that could be further misleading. It is to be hoped that many of these inaccuracies cancel each other out so as to give an overall figure which is of the right magnitude. As data builds up from several such studies a clearer idea will emerge as to whether this is the case.

8. Recommendations

Policy makers and planners working in this field should consider the following recommendations which arise from this paper:

1. Policy makers should be aware of ***the range of computer provision*** available and decide what is most appropriate to their circumstances. Brand new state-of-the-art equipment is not essential for good educational outcomes in the way that suppliers of such equipment and IT professionals like to convince us it is.

2. Careful consideration needs to be given to ***ensuring high levels of usage*** of computer facilities. This is the key to reducing unit costs and ensuring a more cost-effective use of computers in education. Training of teachers and processes of provision are likely to have a critical part to play in this.

3. Careful consideration needs to be given to the ***processes*** involved in computer provision in schools. Processes which are more likely to ensure high levels of usage need to be employed.

4. As the provision of equipment is only a part, often a small part, of the costs of total provision, where sufficient usage can be generated computer labs and telecentre should have ***a minimum of 20 computers***. In this way the high fixed and training costs are spread over a larger number of users and so drive down unit costs.

5. ***Adequate training of teachers*** needs to be incorporated into all plans for computer provision in schools. Without this, expensive equipment too often remains inefficiently and ineffectively used.

6. There is an urgent need to ***develop low-cost***, easily adaptable and replicable ***training packages*** through which teachers can easily acquire basic keyboard competency and computer literacy and quickly progress to learn about educationally beneficial ways to use computers in schools.

7. ***Research*** needs to be conducted ***into actual computer usage*** in schools, the factors which prevent higher usage and how these might be overcome.

8. Appropriate ***benchmarks and ratios need to be developed*** against which to monitor computer provision. Three such benchmarks have been suggested in this study: *i) The annual cost per regular student user, ii) Actual regular students as a % of possible regular students, and iii) Actual regular users as a % of possible regular users.* A ratio of "*the cost of a computer to the total cost of effective provision over a five year period"* is also suggested.

9. Facilitating community and parental usage of computers provides an opportunity to enhance ***school – community relationships***, a factor which can have considerable impact on school effectiveness (see Levin and Lockheed, 1993:10). Careful planning and management is needed to ensure this takes place.

10. Schools are likely to need ***assistance with planning income generating activities*** if this is seen as a way of meeting the running costs of computer provision. Small enterprise development agencies may be an appropriate source of such assistance.

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Appendices

Appendix 1: efficiency calculations

In the different sections where cost data has been gathered an attempt has been made to gauge the efficiency with which computing resources are being used. In order to do this two benchmarks have been hypothesised as follows:

1. The ***"Possible number of regular students"*** is calculated as:
No: of computers x 2 (users per computer) x 5 (school hrs per day) x 5 (days per year) ***= No. of computers x 50***
i.e. there are 50 possible regular student users per computer.

2. The ***"Possible number of regular users if open 10 hours, 300 days"*** is:
the possible number of student users plus the possible number of community users, the latter is calculated as:

No: of computers x 5 (additional hrs. of possible availability) x 6 (days per week when could be open). = No: of computers x 30

Therefore with student and community users ***= No: of computers x 80***
i.e. there are 80 possible regular users per computer

This assumes 10 hrs total usage per week day and 5 hrs per Saturday. It also assumes just one student per computer for community usage**.**

Appendix 2: centrally financed government provision

The Universal Services Agency (USA) was established by the government of South Africa and is funded by contributions from the telecommunications operators as a part of their license agreement. These funds can only be used to subsidise ICT for needy communities in under-serviced areas. Equipment has to pass to a group or organisation which is a legal entity. Field officers assist in the identification of schools and then the whole concept is explained to the school governing body, the principal and the learners' representatives. The local government department of education must also consent, as internet usage can mean a substantial increase in the phone bill which they usually pay. The school must appoint a teacher to manage the computer lab.

Once tenders are issued, bids must be submitted within a month. These are evaluated within a week and awarded two days later. Contractors must then complete installation in ten sites within three months. USA kindly gave sight of the successful bid from their tender in January 2000 to supply 840 computers to 40 schools. The specifications were:

Workstations: PIII 450 MHz, 32 MB RAM, 6.4GB Hard Drive, CD ROM, 15" SVDU monitor, Windows 98, anti virus software (aprox. US$1200)
Server: mainly as above but with 9GB HD (aprox. US$ 2,000)
Router: to access internet via 64 K ISDN line (aprox. US$ 940)
MS Office 2000: licence per machine (aprox. US$77)

All of these prices exclude Govt. Sales Tax at 14%.

Other items included installation and testing of network, printer, burglar proofing, alarm system, wiring, air-conditioning. The successful bid was costed at US$171,871 = $42,967 per school.

These figures are a part of the costs included in the *Micha-Kgasi High School* case study in the "Deluxe" section.

From my conversations it seems that there is a growing realisation that this level of inputs is not adequate to facilitate effective computer usage in schools. In particular it is thought that effective training of teachers is also needed.

Appendix 3: details of community based telecentre provision supplied by USA

Universal Services Agency (USA) organises and procures computer provision on behalf of the government of South Africa (see appendix 2). They kindly gave sight of the successful tender document for the provision of their telecentres. These costs, for June 2000 (excluding sales tax (GST)), include insurance ($950) and training ($583). The main equipment included:

Workstations: PIII 600 MHz, 64 MB RAM, 8GB Hard Drive, CD ROM, 15" SVDU monitor, Windows 98, anti virus software (aprox. US$1,277)
Server: Mainly as above but with 128 MB RAM, 10GB HD (aprox. US$1490)
MS Office Pro 2000: Licence per machine (aprox. US$69)

Tender bids varied between a total cost of $245,033 and $690,279 (excluding GST at 14%). The total of the successful bid was $267,819. For 10 telecentres this gives a figure of $26,782 per centre (exchange rate of $1 = R6). This figure includes the provision of a fax, copier and phones the costs of which are not included in the analysis below.

Figures given below do not include running costs (apart from ISP provision).

Table 18: Cost data for Community Based Telecentres as provided by Universal Services Agency

Cost Category	Govt. provision
Summary of data gathered	
Housing refurbishment, fittings and furniture	$2,614
Equipment: hardware and software	$12,431
Training per year	$583
Running per year (see note 1)	$219
External support per year	
Number of computers	6
Calculated cost data (without full running costs)	
Total annual cost of computers in centre	$2,923
Cost per computer per year	$487
Cost per computer over 5 years	$2,436
Efficiency of usage calculations	
Possible regular users if open 10hrs, 300 days	360
Hypotheticals	
Annual cost per regular user if 80% efficiency	$6.50

Note:
1. The running cost figure only covers ISP provision, **therefore the figures for "Calculated cost data" and for "Hypotheticals" should not be taken as being comparable with the figures in the main text**.

Appendix 4: adjustments made to data received

Their appeared to be errors in some of the data received in this survey. Attempts have been made to clarify the figures where an error is suspected, unfortunately, these have not always been successful. While not wishing to fabricate data, inserting some of the data, as received would have been misleading. It has therefore been necessary to adjust some data in order to arrive at the most realistic figures for total costs and unit costs. In doing this the following changes were made.

Yomela:

1. Under equipment a figure of US$2,205 was given for a network card for each computer. This has been altered to the more reasonable figure of US$50 per card.
2. A figure of US$417 (R2,500) has been taken as an approximation for annual electricity costs (based on Zimbabwe data, but adjusted for differing electricity charges and usage), rather than the figure of R7,500 given which may be for the whole school.

3. A figure for "regular" users was not supplied. As users pay a fee each month for computer lessons the "users" have also been counted as "regular" users.

4. The figure for running costs includes 500 floppy discs at US$1 each not at the cost of US$3.30 given in the original data.

5. A figure of US$48 has been inserted for each the 20 computers sent by Computer Aid International, as this is the unit cost incurred by Computer Aid International .

High Glen:

1. A figure of US$540 has been inserted for the annual electricity costs of running the computers. This has been computed from meter readings taken over a few weeks and is likely to be a reasonable estimate of the cost of running 10 computers and a server for a year at a telecentre in Zimbabwe with an electricity cost of 0.75 US cents per KWh.

2. Student usage figures were not provided but were calculated from notes made during a visit to the centre

Marondera:

A figure of US$3,445 was provided for the cost of annual maintenance. This seemed to be unreasonably high taking 50% of running costs. For High Glen a figure of US$625 was given and for *Bindora* $0 is recorded. Therefore an estimate of US$1,000 has been substituted as a more reasonable figure.

Bindora:

The cost of a modem and power surge protection was not given, the same figures as supplied by *High Glen* have been inserted for these (total US $280).

Ngaka Maeseko:

A cost of US$1,700 has been estimated for the donated server.

Bishops:

1. Costs were provided, as requested, for just one lab. The provision at *Bishops*, as briefly outlined in the text, is much greater than this. In order to more accurately portray the total cost of provision at *Bishops* the following changes have been made. The lab costs have been doubled, costs have been included for eight servers at US$6,666 each, costs of the fibre optic network estimated at US$83,333 have been inserted. In addition to this the total costs of 400 lap-tops estimated at US$680,000 has also being inserted. The costs of the servers may be a slight over-estimate but this should be cancelled out by other costs not included e.g. the refurbishment costs of the classrooms.

2. Power costs estimated at US$1,500 have been inserted. This could well be an underestimate.

SOS:

A figure of US$472 was given for power costs. This is derived by looking at the school's annual power consumption before the computer lab was installed and comparing with the annual consumption with the lab. This figure has then being doubled to take account of the additional computers. Likewise the figure for maintenance has also been doubled.

Micha-Kgasi:

1. A figure of US$700 has been added as an estimation of the power costs of running the computers. This does not include an estimation for the cost of running the air-conditioning which has been installed.

2. Training costs for WorLD courses are for marginal costs only. For the basic computer literacy courses the lowest of the figures provided by Ngaka Maeseko have been used (US$25 per course).

3. Gave a figure for 350 reams of paper used per year and 10 toner cartridges. These have been changed to the more reasonable figure of 35 reams and 2 cartridges.

Mutoko:

As *Mutoko* has only just become connected to the web the charges for phone calls to the ISP have been estimated based on 14c per minute. This is US$8.40 per hour and $168 per month for 20 hours usage. This equals $2,016 per year.

Cost comparisons:

The cost of a Grade 9 text book was only provided by *Marondera*. A figure of $6.61 was given as the cost of a Maths text book and $8.63 was given as the cost of a science text book. A figure of $8 has been used for *High Glen* and for *Bindora* and *Marondera*. The annual salary of a Newly Qualified Teacher provided by *Marondera* has also been used for the other Zimbabwe telecentres.

Appendix 5: reflections on this research and what can be learnt for future research.

As mentioned in the introduction the data on which this research is based was gathered using a case study approach at a micro level. A framework was developed with five main categories through which to analyse cost data. Individual schools, telecentres and training providers were visited in Zimbabwe and South Africa, the framework was explained to teachers, bursars and managers, many of whom used it to gathered data and forwarded this for analysis and incorporation into this study.

Reflecting on this process for future work it is recommended that the following are borne in mind:

1. Keep the framework as simple as possible.

In consultations to develop the framework for gathering the data many suggestions were made regarding additional data which it would be useful to gather. Examples of this included the size of servers in use so that the MGB per students could be calculated and the sources of finance for computer provision. While all suggestions identified additional data that it would be useful to gather, their cumulative effect was to make the framework more complicated and, I would guess, off-putting than it need have been. As a result the process of gathering the data was more time consuming than anticipated. This meant that not all establishments provided the data, and that for many of those that did, the data was incomplete and possibly less accurate than it could have been.

2. An in-country co-ordinator is needed.

Once schools or telecentres were visited and the framework was left with them to be completed, there is a considerable amount of follow-up work that is needed. This mainly involves progress-chasing and then clarifying the data submitted. In the countries featured in the research the WorLD co-ordinators undertook this work as best they could, but often it was too great an intrusion into their time.

If such work is undertaken in future it would be advantageous to hire a part-time co-ordinator for a few weeks to undertake this task.

3. A direct incentive may be needed to encourage those gathering the data to do so in a timely manner.

The teachers and administrators who provided this data all did so in their own time without any direct rewards. While much research and development work is dependant on such generosity and while no-one would wish to move more into a world where people will only undertake such work if they are paid to do so, it has to be recognised that school teachers and administrators have many competing demands on their time and generosity. The gathering of data for this type of research is likely to happen more quickly and easily if some form of direct incentive is given to those participating in it as an acknowledgement of the time they give. This could be in the form of a small payment or a gift of equipment or software to themselves or their establishment, or a combination of these.