Investing in ICTs in educational institutions in developing countries: An evaluation of their impact in Kenya

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ABSTRACT

The incorporation of Information and Communication Technologies (ICT) into the educational curriculum has been promoted as a key step in bridging the digital divide. Despite considerable growth in the numbers of computers acquired by schools in Kenya in recent years and the sacrifices made to finance these, there has been little evaluation of their effectiveness. Consequently, this research seeks to redress this by examining the impact of ICT projects in educational institutions in Kenya. Teaching staff, current students and former students together with parents of current students were surveyed. Key informants were also interviewed to establish the current policies concerning ICT in education in Kenya. An absence of educational software was found, as was the lack of Internet access and use of e-mail. Some 35-40% of secondary school teachers had never used a computer. The research revealed tangible benefits to students from exposure to ICT. It was also found that exposure to computers in schools influenced the career choices of former students. It was concluded that reform of the telecommunications sector is necessary to hasten the rollout of computer technology in educational institutions in Kenya. At school level, the key issues which arose included staff training, mainstreaming of ICT across the curriculum and provision of adequate ICT equipment.

Keywords: ICTs; Developing Countries; Education

INTRODUCTION

This paper investigates the use of computers in educational institutions in the Rift Valley province in Kenya. The adoption of Information and Communication Technologies (ICT) has been promoted as a key step in bridging the digital divide. Despite considerable growth in the numbers of computers acquired by schools in Kenya in recent years and the sacrifices made to finance these, there has been little evaluation of their effectiveness. Consequently, this study examines ICT projects in educational institutions in Kenya, in order to establish normal practice and to determine the effects of adopting ICTs at school level.

BACKGROUND TO THE RESEARCH

The country of Kenya experiences many of the problems typical of sub Sahara Africa enumerated by Langmia (2006) in that it is lagging behind in information superhighway technology. In terms of telecommunications infrastructural developments, the growth of the fixed telephone network throughout Kenya has been below expectations; according to the Central Bureau of Statistics (2006), the fixed line tele-density was 1.02% (number of fixed lines per one hundred population) during the year 2003 but this has actually deteriorated since then due to the steady population increase in the absence of infrastructural developments. Most of these fixed line subscribers are concentrated in urban areas which account for 94% of the fixed lines while 6% are in rural areas (ibid). In contrast, cellular services have expanded rapidly from under 15,000 customers in 1999 to over 2.8 million in 2004 (Export Processing Zones Authority, 2005). By April 2004, there were

an estimated one million internet users and over one thousand cyber cafes throughout the country (ibid.).

Keiyo District is one of 18 districts of the Rift Valley Province and lies just north of the equator, at its centre approximately 350km north west of Nairobi. The western and southern areas of the district are fertile and support the highest population. Livestock rearing and tillage farming are the main occupations of the community. To the north of Iten, the administrative centre, the land gradually rises through forests of indigenous trees and bleak high merino-sheep country. Lumbering is also carried on in this area. The total population of Keiyo District was estimated at 144,000 in 2004, and the population density was estimated to be 100 persons per square km (CKRC, 2004). Keiyo District is the eighth most densely populated district in the Rift Valley Province and has an average life expectancy of 61 years.

There are 174 primary schools in Keiyo District and the primary school enrolment rate is 98.4%. The total number of pupils who sat the Kenya Certificate of Primary Education (KCPE) in 2004 was 4,922. A total of 2,471 places are available in the 32 secondary schools in Keiyo District, so, at best, only half of primary school leavers in the District can be accommodated locally. The current education system allows for a certain proportion of Keiyo primary school leavers to take up places in neighbouring districts or other provinces but this is offset by students from outside the district who take up places in Keiyo secondary schools. Due to the competitive nature of secondary school enrolment, approximately half of all primary school leavers in Keiyo District will fail to secure a place in secondary schools, which conforms to the national average.

This remainder of this section is presented in two parts: firstly the contribution that ICT can make to development through education is explored and secondly some relevant studies previously conducted on integrating ICT into the educational curriculum in Kenya are critiqued.

Contribution of ICT to Development

Education is a prerequisite for achieving several development goals. Research has shown that education is positively associated with a wide variety of human welfare issues that are seen as development goals. For instance, Lockheed et al. (1980) found that in a modernising environment four years of education improved agricultural productivity by 10 percent. Education is crucial to effective poverty reduction strategies (World Bank, 1995, p.1). Tilak (2002, p.198) argued that there is much research to support the hypothesis that education and poverty are inversely related. Education plays a vital role in improving the health and longevity of populations; even a basic education resulting in literacy and numeracy enables people to gain and employ potentially life-saving knowledge about nutrition, hygiene and sanitation. Health and education are mutually reinforcing; a study by the Global Campaign for Education (2004) suggested that if Universal Primary Education (UPE) is realised then an estimated 700,000 young people could be prevented from contracting HIV/AIDS. Indeed, they posited that education is the most effective weapon to fight the spread of HIV/AIDS.

The World Bank and UN agree that the social benefits alone of female education outweigh the costs without even considering the private benefits or increased productivity and earnings (Todaro and Smith, 2003, p. 377). Educating females has enormous potential to create a virtuous circle, as the children of educated mothers are more likely to receive an education. The benefits of educating mothers are invariably passed on to children. Glewwe (1999) studied health data in Morocco and found that mothers with numeracy and literacy skills attained through school possessed greater health knowledge and consequently had healthier children.

One of the dynamics of the lives of people in the grip of poverty is disempowerment – a lack of control over decisions made both by them and for them. ICT promises to go at least some way

towards empowering them by removing barriers to the access to information. Prahalad and Hart (2002, p.9) considered that information poverty may be the single biggest roadblock to sustainable development. Commentators from diverse political persuasions are convinced that ICT offers a potentially valuable tool for development (Annan, 2001; Nulens et al, 2001, p.10 and Ya'u, 2004, p.25). Appropriate use of ICT could enhance many aspects of life in developing countries from health to education to economic growth. Education is one area where ICT deployment and improved access to information promises to deliver tangible benefits. ICT lends itself to adopting a more people or learner-centred approach to education. Freire's liberation theory (1970) stresses the importance of a dialogical approach to education. ICT can facilitate a pedagogical shift entailing an educational interaction between teachers and learners. ICT, if used correctly, can encourage and support a meaningful two-way, informational flow between teachers and learners, moving away from the old "banking" method of teaching where knowledge is simply transferred from teacher to student without any space for critical analysis on the part of the learner. Using ICT in education to produce ICT-literate students and a versatile, adaptable workforce is also consistent with the human capital theory of education. Hawkins (2002, p. 39) states that workers must learn how to learn and quickly acquire new skills. Augmenting the skills of the workforce in this way has the potential to benefit the economy at large and also improve the individual student's earning and employment potential.

In specific terms, there are several ways in which ICT can contribute to solving education problems in Developing Countries; some of the most pertinent of these problems include:

- Shortage of qualified teachers: GeSCI (2004) estimated that as many as 25% of teachers in sub-Sahara Africa are not adequately qualified; ICTs can accelerate teacher training and the Imfundo Report (Unwin, 2004) concluded that ICT in education has most potential in pre- and in-service teacher training.
- Low learning achievement: Introducing ICTs can help to counter some of the negative factors endemic in many schools in Developing Countries, such as high pupil: teacher ratios, shortage of basic instructional materials and poor physical infrastructure. Research on the Digital Education Enhancement Project in the Eastern Cape of South Africa (Leach, 2003) found that ICTs had a positive impact on pupil achievement and classroom practice.
- High drop-out rates: ICT can be used to make the school curriculum more interesting. Studies have verified that children enjoy learning using technology (Hepp et al., 2004; Osin, 1998). This motivation may deter children from dropping out of school; Gómez and Martinez (2001) described how using the internet in education programmes for street children in Colombia enticed a higher than usual number back to learning.
- Lack of opportunities in remote areas: Distance learning can help to overcome the problems associated with geographical isolation and is invaluable for students in remote areas. Distance learning educational software also benefits from economies of scale increasing cost efficiencies. Recruiting teachers for the more remote regions is often difficult in Developing Countries; ICT serves to counteract physical distance as teachers can maintain contact with family and friends through telephone and e-mail.
- Lack of study material and resources: Study and teaching materials are very sparse in many schools in Developing Countries; ICTs can play a significant role in providing teachers and students with access to educational content and up to date resources.

The issues arising from the preceding paragraphs lead toward the conclusion that education is one of the most important elements for achieving development success. However, ICT in turn can contribute towards enhancing education. This relationship was succinctly summarised by Kofi Annan (United Nations, 2003) when he asserted that:

> *"While education unlocks the door to development, increasingly it is information technologies that can unlock the door to education"*

The Government of Kenya sees education as the natural platform for equipping their nation with ICT skills in order to create dynamic and sustainable economic growth (Kenya Government, 2004a, p.67). Apart from the traditional use of ICTs in education "as a vehicle for improving existing school curricula and school management processes" (Makau, 1990, p.3), the Kenya Government holds that the use of ICT in education and training institutions will play a major role in disseminating skills to the wider society and thus create positive impacts in the economy (Kenya Government, 2004a, pp.67-68).

ICT in Education in Kenya

Although ICT in education in Kenya is a relatively new area of research, some useful publications are available, dating back to an evaluation of one of the earliest computer deployment projects in the country, the Computers in Education Project in Kenya (CEPAK). The latter project was launched as long ago as April 1983 but its evaluation in 1990 is particularly relevant to the present research. At its pilot phase, with funding from the Aga Khan Foundation, a small number of computers were introduced into one secondary school in Nairobi. In the succeeding two years CEPAK was subjected to both in-house and external evaluations. As a consequence, additional funding was obtained from Apple Inc., the International Development Research Centre (IDRC) and the Rockefeller Foundation, and in mid 1986 a three-year Phase II was launched. Five more secondary schools, which included private and public schools distributed throughout Kenya were brought into the project and each received computers, software and teacher training. During the three year period of Phase II, this innovative project was studied and evaluated by an independent research team (Makau, 1990). Three educational researchers carried out this study, using a variety of research methods; these included examination of school records on the use of computers within the six participating schools, observation of classes (91 were observed, 65 of which were computer-assisted), and interviews with students, teachers and non-teaching staff. Two sets of written questionnaires were administered to teachers and students in 1986 (baseline year) and in 1988. In total, 170 teachers responded to these questionnaires in 1986 and 110 in 1988. For the students, 1535 responded in 1986 while 2671 responded in 1988. Thus, this represented a large-scale study of the use of computers in secondary schools in Kenya.

The CEPAK evaluation found that most computer-assisted lessons were observed to be in mathematics and the sciences. However, this evaluation also found that in the majority of computer-assisted lessons teachers tended to be passive, thus leaving students to do whatever they chose. It found that some students regarded both formal and informal sessions on the computer as time for relaxation as opposed to serious learning (Makau, 1990, p.160). This approach to computer-assisted lessons was explained as being a result of the perception of the computer as the object of study, as more exciting and potentially more rewarding than integration of the technology into the existing curriculum (ibid. p.90).

The research also found that computer studies lessons were conducted in the computer laboratory, thus they seemed to have priority over computer-assisted lessons in other subjects. It would appear that, both practically and symbolically, computer science was receiving more emphasis than integration of the technology into the rest of the curriculum (ibid. p.91).

The evaluation also provided some very interesting findings with regard to gender issues in the use of computers. As with the findings of the current research (discussed below), no significant differences in the attitudes of boys and girls to the new technology were unearthed (ibid. p.161). However, with regard to exposure outside the school (i.e. at home, in primary school or elsewhere), female students were more disadvantaged than their male counterparts. The proportion of males that claimed to come from a home which owned a computer was nearly twice that of females, while 21% more boys than girls claimed to have used a computer outside school

(ibid. p.161). Even more worryingly, in mixed schools surveyed in the evaluation, female students claimed to have received less in-school exposure than the males (ibid. p.163).

A second research project (Kenya SchoolNet, 2003) conducted in November 2002 was based on the findings of a questionnaire to which 69 secondary schools responded, coming from all provinces and 46 districts. This research reported that only 46.4% of the sampled schools had computers although there did appear to be a high level of awareness of the benefits of computers in schools (ibid. p.11). The research also reported that Internet and fax were rare in the schools (ibid. p.10). It was suggested that E-mail was yet to be recognised as a tool for collaboration among teachers as only one school had a website and only two reported having networked all their computers to the Internet (ibid. p.20). It went on to assert that in those schools, access to the Internet was severely limited and when available, was only for administrative use (ibid., p.20).

The Kenya SchoolNet research found that almost 40% of schools had less than 10 computers, and therefore inadequate numbers for teaching and learning. More than 20% had less than 5 computers, indicating that the computers were largely for administrative purposes (ibid., p.10). Only one third of schools surveyed had dedicated computer laboratories. The research also found that some schools were making use of very old equipment and that heavy reliance on the donation of computers as opposed to sourcing locally reduced the capacity of the school to determine the makes of computer they used (ibid. p.13).

As with the previous research reported from the CEPAK project, the Kenya SchoolNet survey also revealed that there was a significant difference in the quality and use of the computers in schools, depending on the gender of students there (ibid., p.23). Girls' schools were found to have the lowest numbers of computers, almost a third of that of boys' schools (ibid., p23). The survey asked if computers were used for teaching and found that more boys' schools than girls' reported in the affirmative (ibid., p.24). Furthermore, the survey found that fewer of the computers were located in a computer laboratory in girls' schools, indicating their use predominantly in administration in girls' schools. The research concluded that fewer girls were being exposed to computers than boys (ibid., p.24).

Again, mirroring closely the findings of the evaluation of CEPAK, the Kenya SchoolNet survey found that there was a close association between mathematics and computer usage given that many computer teachers were themselves teachers of mathematics. This tendency created a perception that computer courses were closely linked to mathematics, and in turn explains why fewer girls than boys took computer lessons. Consequently, the research concluded that girls would be marginal players in the information society (ibid., p.30).

A third research study (Ndiku, 2003) conducted more recently and based on the experience of managers and computer teachers in eight schools in Uasin Gishu District, western Kenya, focussed on the problems encountered in the implementation of educational ICT projects. The research identified the following as the most important factors in inhibiting the success of computer deployment projects: insufficient numbers of computers and peripheral devices; teachers' lack of knowledge; inadequate software for instruction and inadequate technical assistance (ibid, p.81). Computer teachers themselves were found to have the additional problems of integrating computer usage into the school curriculum and frustrations with out-dated computers which were not relevant to current needs (ibid. p.81).

These studies of ICT in education in Kenya have highlighted some of the issues specific to ICT deployment in schools. The present paper now attempts to contribute to the research in this area with an evaluation of current practice in educational institutions in Kenya with a view to establishing best practice in educational ICT deployment projects.

St. Patrick's High School, Iten was selected as representative of a typical secondary school in rural Kenya. As is the case with the vast majority of successful secondary schools in Kenya, it is a boarding secondary school, and draws its intake from a wide geographical area. Admission is based on students' results in the Kenya Certificate of Primary Education (KCPE). The school is designated "Provincial" which places it in a middle ranking in terms of the academic achievement of its Form One intake (above "District and below "National"). The school is based on the outskirts of a small rural village and has electricity, telephone and is covered by both mobile telephone operators. The school is also typical in terms of numbers of staff and students, with approximately thirty full-time equivalent staff and 550 students. It is an all-boys school. However, segregation is the norm in Kenya, but to provide balance and examine any differences in the implementation of ICT programmes that may arise, a "Provincial" boarding school for girls, Singore Girl's Secondary School, was also selected for the purposes of this analysis. Singore Girls is somewhat smaller in size than St. Patrick's in terms of staff and student numbers with approximately twenty staff (full-time equivalent) and four hundred students. Form One intake is again based on the results of the KCPE, and in terms of the geographical spread and academic level of Form One intake, is broadly similar to that of St. Patrick's.

In terms of access, St. Patrick's High School is located on a good tarmac road, 30km from Eldoret town, which is 320km from the Kenyan capital, Nairobi. Singore Girls' is a further 6km from St. Patrick's on the Kapsowar road. This is a mud road and required a four-wheel drive vehicle, as research was carried out between June and August which was the rainy season in this region. Frequent visits to both schools were made, and no problems were encountered. The third educational institution examined was Baraka Agricultural College, Molo. This is also located on a good tarmac road; however the road from Eldoret to Molo is in a bad state of repair.

RESEARCH OBJECTIVES

The overall aim of this research is to evaluate the implementation of ICT projects in selected educational institutions in Kenya with a view to making recommendations on how such projects should best be deployed and supported. The following specific objectives were identified:

1. To describe and critique the current situation in selected educational institutions with regard to ICT usage;

2. To evaluate the ICT learning programmes for students and to assess levels of interest in and attitudes towards ICT among students, teachers and parents;

3. To assess the positive impact of ICT exposure in the lives of students and the improving practices that have resulted; and

4. To issue recommendations on how problems might be overcome and how supports might be enhanced to maximise the learning and benefits that result from an ICT project in a typical Kenyan school or training college.

RESEARCH METHODOLOGY

While the research focussed on three educational institutions (St. Patrick's High School, Singore Girls' Secondary School and Baraka Agricultural College), visits to additional institutions were made for the purposes of verification. The research was designed as both a quantitative and qualitative survey using interviews, questionnaires and observation. The research methodology was designed to facilitate a critique of current practice based on the results of these interviews, questionnaires and observations.

In summary, the following sources provided data for the study:

• Management staff from four secondary schools and one agricultural college;

• Teaching staff from two of these secondary schools and the agricultural college;

• Current students from these two secondary schools and the agricultural college;

• Former students from one secondary school;

• Parents of secondary school-going students;

• Key informants from the ICT, education and telecommunications sectors in Kenya.

Specifically, the following research methods were employed:

• In-depth semi-structured interviews were conducted with key members of management staff in four secondary schools in Keiyo District, and Baraka Agricultural College, Molo during July and August, 2005. In St. Patrick's High School, the Principal, the Head of the IT Department and the Computer teacher were interviewed in person. In Singore Girls' Secondary School, the Principal and the Head of the IT Department were interviewed in person. In Kessup Girls' Secondary School, the Principal, Head of IT and one Computer teacher were interviewed in person, while from Kaptagat Girls' Secondary School, the Principal was interviewed by telephone. Four in-depth interviews were personally conducted in Baraka Agricultural College with the Principal, the Deputy Principal, the college IT Coordinator and the Head of the Community Development Department. The purpose of these interviews was to establish background information on the schools concerned and to gather factual information on how ICT was incorporated into the school curriculum. The issues explored ranged from the experiences with deployment of ICT at school level to the attitudes of these staff towards ICT.

• Teachers from three of the institutions mentioned above were interviewed in person during June/July 2005 using a structured questionnaire. Twenty of the thirty teachers from St. Patrick's High School were interviewed, all twenty teachers from Singore Girls' Secondary School were interviewed and eleven teaching staff from Baraka Agricultural College were interviewed. The issues raised focussed on the respondents' teaching responsibilities, their specific experiences of using computers, their attitudes towards integrating computers into the curriculum and using computers to teach their subjects. Details relating to their personal characteristics and academic qualifications were also investigated.

• Samples of current students were randomly selected for interview from both St. Patrick's High School and Singore Girls' Secondary School. A structured questionnaire was personally administered in June/July 2005 by one of the researchers. Twenty students from St. Patrick's (from a population of 550 students) were interviewed; these consisted of ten from lower forms and ten from senior forms while sixteen students from Singore Girls' Secondary School (from a population of 400 students) were interviewed (eleven of whom were from junior forms and five from senior forms, to reflect the population from which the sample was drawn). All students in Baraka Agricultural College (90 students) were surveyed using a questionnaire administered by the Head of the Community Development Department when the students joined the college in July 2004. The questionnaires explored the students' experiences with using computers both at primary and secondary schools, investigated in depth the students' exposure to computers and determined their attitudes towards computers in the school curriculum. Personal questions were also asked in order to examine the characteristics that were associated with these experiences and attitudes.

• Twenty-nine former students (all graduates from the class of 2005) of St. Patrick's High School were invited to participate in the research. These consisted of nineteen who lived locally and an additional ten from further away. All nineteen former students who were

identified as living locally were invited to participate in the study. They were asked in person to complete a structured questionnaire by one of the researchers in June/July 2005. Among the former students who did not live locally, ten were selected at random and invited by post to complete the questionnaire and return by post. All ten responded, thus resulting in 29 completed questionnaires. The questionnaires administered to former students sought details about their experiences with computer classes during their primary and secondary schooling and asked the respondents to evaluate their familiarity and current levels of competence with a range of computer applications. In addition, these former students were asked to comment on their current access to computers and to report on the purposes to which they were using computers since leaving school. They were also asked about their career aspirations and if they were using computers to realise these.

- Ten parents of secondary school-going students from the Iten area were randomly identified and invited to participate in the research. All ten agreed and were personally interviewed using a structured questionnaire during June and July 2005. Their questionnaire focussed on their personal and family circumstances, their own experiences with computers and the importance that they attached to their children being able to use computers.

- Four key informants were interviewed in person to provide additional information on the ICT, education and telecommunications sectors in Kenya: these consisted of the District Education Officer, Keiyo (Kenya Government), the National IT Co-ordinator from the Kenyan Ministry of Education, a Manager from ICT Trust Fund, Nairobi and a Technician from Telkom Kenya.

The data collected to evaluate the teaching and learning programmes at these educational institutions were presented and analysed using the logic of Bennett's Hierarchy (after Bennett, 1975). First used in the 1970s to guide the evaluation of Extension programmes, this hierarchy continues to be updated and used for planning and evaluation of broad-based development programmes (see, for instance, Fisher et al, (2001), and is ideal for evaluating educational programmes.

The seven stages of Bennett's Hierarchy of Evidence may be summarised as follows:

7. Impact–Social, economic, environmental conditions intended as end results, impacts or benefits of the programme.

6. Actions–Patterns of behaviour, such as decisions taken, practices implemented, actions taken, technologies used etc.

5. Learning–Knowledge (awareness, understanding, and/or problem solving ability); Attitudes (outlooks, perspectives, viewpoints); Skills acquired; Aspirations (ambitions, hopes).

4. Reactions–Degree of interest; feelings towards the programme.

3. Participation–Numbers of students reached; characteristics of students; extent and intensity of exposure to programme.

2. Activities–Educational methods used; subject matter taught.

1. Resources–Staff time; salaries; resources used: computer equipment etc.

This seven-stage hierarchy is based on a logical progression of evidence required to conduct an evaluation. The lower stages of Bennett's Hierarchy represent the resources (1) involved in implementing the programme of activities (2) intended to achieve the participation (3) of the students. As the hierarchy is ascended participants' reactions (4) to programme activities are measured to determine how these activities affect their learning (5). This fifth stage of the

hierarchy looks at changes in what Bennett calls 'KASA' i.e. students' knowledge, attitudes, skills and aspirations. After learning, people take action (6) which will have a social, economic or environmental impact (7). Bennett's thesis is that evaluations are strengthened by collecting data at several stages of the hierarchy.

The data collection phase of the study involved visits to the institutions under examination and observations of their ICT programmes. Information on resources, activities and participation was collected through the semi-structured interviews with the Computer teachers and ICT Co-ordinators and school or college management. For the higher levels of Bennett's Hierarchy – impact, reactions, learning and actions – evidence was garnered from both structured in-depth interviews with current and former students and the series of questionnaires designed for parents and teachers.

Quantitative data (results of questionnaires) were entered into the Statistical Package for the Social Sciences (SPSS 11.0® for Windows) software and analysed using this data manipulation programme. Descriptive statistics (Frequency distribution, percentages, measures of central tendency and variability) were used to describe the data. Crosstabulations were used to examine relationships between variables while Pearson Chi-Square (with a 0.05 level of significance) was used to test significant differences. This methodology is typical in evaluation research (see, for instance, Kistler and Briers (2003),

The quantitative data were supplemented with qualitative information. The key informant interviews provided very valuable insights into the levels of awareness among interviewees. Civil servants, even those charged specifically with a role in education and the provision of ICT resources and information to schools, seemed poorly informed as to the kinds of educational ICT resources available, the funding options available to schools and colleges and the very potential itself of ICT in education. By contrast, at school and classroom level, the response was much more encouraging. It almost seemed as if schools and colleges rolled out their own ICT projects in spite of the official infrastructure in place rather than because of it. The key informant interviews also proved to be a very useful tool for gathering information on the ICT, education and telecommunications sectors in Kenya. It gave the freedom to the interviewees to include a wide range of information in the discussion and share any personal views held about the current situation and possible future developments.

RESEARCH FINDINGS

The findings below are presented according to the objectives of this research paper. Findings from field research conducted are analysed in order to understand current practice in the three institutions surveyed. Programmes of teaching and learning with ICT are scrutinised using data from personal observations, documentary analysis and key informant interviews.

Current ICT Usage in Education Institutions

Half of Keiyo District's 32 secondary schools had at least some computer equipment installed (information made available by the Education Office, Keiyo District). Just over half of those (28% of all schools) offered computer lessons to students. The average number of machines at the disposal of students in those schools that offered lessons was 15, the highest recorded was 21, and the lowest was 10. The ratios of students to computers in the institutions surveyed were as follows: St. Patrick's, 25:1, Singore, 32:1 and Baraka, 4:1. No institution, however, had more than two students per machine during lessons.

In St. Patrick's, the computer laboratory had 16 working machines, with an average of 1.5 students per machine. Singore Girls' had a laboratory with 10 machines, and an average class size of around 15, or a ratio also of 1.5 students per computer. In Baraka Agricultural College, students had access to a computer laboratory with 12 PCs. Only 12 students attended classes at any given time, allowing for a ratio of 1:1.

The software installed on these PCs for use by students came exclusively from the Microsoft Office® suite of programmes (Word, Excel, etc). In addition, Operating Systems in use were exclusively versions of Windows®. The cost of licences for these software packages was prohibitive for most educational institutions. No educational software in any subject was found. In school management, use was made mostly of Microsoft Excel® for book-keeping and Word® for letters and reports. No secondary school in the Keiyo District exploited the resource of the Internet for educational purposes, though Baraka Agricultural College had recently installed an "always-on" connection, and enjoyed access albeit at a very slow speed.

Some 40% of secondary schools in the district were served by fixed wire telephone, although all parts of the district were found to be covered adequately by at least one of the two mobile telephone service providers. Of the three institutions surveyed in this research, only Singore did not have a fixed line. Two of the secondary schools in the district claimed to have e-mail addresses on their official notepaper, though only one had an active e-mail account. In no secondary school was either e-mail or Internet accessible to students, and in the one school where e-mail was used it appeared to be as much for the personal use of the school Principal as for official school business. Baraka Agricultural College did, however, have a leased line from the national phone company, Telkom Kenya, and an 'always on' connection to their ISP. Students there were able to access the Internet for both personal and research purposes.

Only one secondary school in the district (one of the secondary schools which was the subject of this research) had an active website, i.e. www.itensaints.com. It is managed and maintained in the USA by a group of former students from St. Patrick' High School. There is no up-to-date news from the school on the site, but there are several articles and many pictures of interest pertaining to the history of the school. In 2002, the Principal agreed that the site would be the school's official website, however since then, neither he nor the computer teacher in St. Patrick's have had any contact with the individual who manages the site. In contrast, Baraka Agricultural College had an active and regularly-updated website which was managed internally.

An impressive 88% of the secondary schools in the district (and all three of the education institutions surveyed) had electricity from the national power company, Kenya Power and Lighting (KPLC). Penetration of the electricity network was well above the national average in Keiyo District which had benefited from powerful political representation over the years.

Funding for ICT deployment was found to have been raised locally in the case of the two secondary schools examined. This was confirmed as the norm through visits to other schools. However, considerable donor funding has been made available to Baraka Agricultural College. Two of the 32 schools in the district involved private companies in the provision of equipment. One of these was Singore Girls' Secondary School: it acquired PCs through an arrangement with a Nairobi-based private firm, Regio-Tech Ltd. (RT), which is involved in the deployment of computers to primary and secondary schools throughout Kenya. A ten-year contract was signed in September 1998. The firm supplied the hardware, software and the teacher for the duration of the contract, by the end of which the equipment will be fully owned by the school. Prior to the end of the contract, however, the equipment remains the property of RT, and when used by the computer teacher for income generating purposes such as providing lessons for local people or typesetting and printing for commercial purposes, the proceeds are submitted to the company.

The obvious attraction of this arrangement was the immediate provision of ten computers, together with a qualified instructor and a guarantee of servicing and maintenance over the period of the contract. The Headmistress at the time admitted to having no expertise in the area of ICT, although she was under considerable pressure from parents to introduce computers. A glance through the newspaper archives reveals a very similar story in other schools assisted by RT. One Primary School Head-teacher in Nyanza Province described his delight at the arrangement and his relief that the firm "will protect us from dubious experts now all over" (Daily Nation, 9th August 1999).

Funding for the students' Computer Laboratory in Baraka Agricultural College came from a donor agency, and several machines in the administration were also donations. Approximately 15 reconditioned laptops and 4 desktop computers were recently donated. The IT Co-ordinator explained that, while warmly welcoming this equipment, there had been some problems on occasion, such as the requirement to pay excise duty, the out-dated software loaded on some reconditioned machines, and their incompatibility with the network and software already in use.

Experiences of Teaching & Learning Programmes in Education Institutions

The experiences of students, teachers and parents are presented below. The problems that arose and successes experienced in these educational ICT deployment projects laid the foundations for the recommendations on best practice presented in the final section of the paper.

Students' Experiences

In regard to the students surveyed, it was found that half of all boys interviewed in St. Patrick's (n=20) had used a computer before joining the school, however for the girls (n=16), the figure was just over 30%. A direct relationship was found between choosing Computer Studies as an optional subject for the Kenya Certificate of Secondary Education (KCSE) and having had experience with computers before joining secondary school. This may go some way to explaining the lower number of girls than boys who chose to take Computer Studies to KCSE level. Of the group interviewed in St. Patrick's who had chosen to take Computer Studies to examination level in Form Three and Form Four (n=10), 90% had used a computer before joining secondary school.

A teacher-led approach was evident with considerable emphasis on the textbook and theory in the upper Forms in St. Patrick's. This is confirmed by the high percentage (87.5%) of lower Form students who said they worked in groups *often*, *mostly* or *always* compared to only 40% of Form 3 and 4 students who said the same. Singore Girls' School seemed to follow the more active participation and student-centred model in evidence in the lower forms in St. Patrick's.

A very high level of interest among students was found in computer lessons, particularly in the lower Forms. Some 90-94% said that they found computer lessons *more interesting* or *much more interesting* than other subjects. This is very encouraging, and indicates success in the implementation of the ICT projects examined in this research.

Students were also asked to rate their levels of satisfaction with the quality of computer equipment, textbooks, handouts or additional written resources given by the computer teacher, computer assignments and assessment tests in computer lessons. These constituted a subjective measure of quality based on students' own assessments and the purpose was not to rate computer equipment, textbooks, handouts, assignments and assessment tests but rather to give an indication of the students' level of satisfaction with them.

More than 40% of students interviewed (N=36) rated the computer equipment in their schools as *very good* (44% in St. Patrick's and 42% in Singore). The remaining students rated it as *good* for the most part (39% in St. Patrick's and 58% in Singore) but there was a significant number (17%) in St. Patrick's who gave only a *moderate* rating. None of the interviewees from either school gave a *poor* or *very poor* rating, indicating that overall satisfaction with computer equipment was high (85%-88%).

Almost 40% of students in St. Patrick's rated their computer studies textbooks as either *poor* or *moderate*. The girls in Singore were less critical but 17% rated the textbooks as only *moderate*. The most common rating in both schools for textbooks was *good*, so, although satisfaction levels were lower than for the computer equipment, overall satisfaction with textbooks was still high (74%-82%).

Handouts and additional written resources related to computer lessons were rated the lowest among all aspects of the computer courses undertaken by students in both schools (these had satisfaction levels of 65%-77%). Some 28% of students interviewed in St. Patrick's rated handouts as *poor* and only one in three students felt the quality of computer-lesson handouts was either *good* or *very good*. Again, the students interviewed in Singore girls' were not as critical as the boys, but satisfaction among the girls was at its lowest in this category at 77%. One in three girls ranked handouts as *moderate*, however a large number (over 60%) maintained there were too few (or no) additional written resources handed out to rank, especially girls from the lower Forms. This was a significant finding, especially given that the dynamic nature of the subject demands up-to-date additional resources are used for successful teaching and learning to take place.

The results from the two schools in the national examination from the previous year (2004) indicated that boys performed better than girls in Computer Studies. The mean score in St. Patrick's was 8.33, while that of Singore was 6.81 [Subject 'mean score' is a numerical scale from 0 to 12 used in Kenya to present examination results. 12 (the maximum) is an A, 11 is an A-, 10 is B+ etc.]. This could be explained by any number of factors including the fact that more boys attended primary schools with computers (25% compared with 12% of girls) and more boys had exposure to computers outside secondary school (50% of boys compared with 30% of girls). It was also observed, while visiting these schools, that boys were more interested than girls in computers and were performing more challenging tasks on the computers. Informal discussions with these children also suggested that boys appeared to be more aware of the possibilities of the Internet, for instance in relation to career options in ICT.

Teachers' Experiences

The research found that there were no computers in the two secondary schools surveyed set aside for use by teachers. This was a concern raised by the teaching staff. One teacher complained about having to share the facility with students, especially given the confidential nature of some of the work that teachers need to prepare on computer. It was also felt that learning to master the new technology in the company of students was inappropriate and at times embarrassing. In Baraka Agricultural College, where the deployment of computers in administration was most impressive, every office had at least one computer, a printer and a connection to the Internet. In contrast with the secondary schools, these facilities at Baraka greatly facilitated teachers in improving their computer skills.

The findings revealed a clear trend between the year of graduation of teachers and whether or not they ever used computers outside the workplace, with the older graduates less likely to have used one (see Table 1). Some 35-40% of secondary school teachers admitted never having used a computer at all, either in school or outside of it.

Table 1: The relationship between the year of graduation of teacher respondents and whether or not they used a computer outside the workplace (n=51).

			Graduation Year (categorised)			Total
			1980-1990	1991-1996	1997-2005	
Have you ever used a computer outside the workplace?	Yes	N.	7	11	14	32
		%	36.8%	64.7%	93.3%	62.7%
	No	N.	12	6	1	19
		%	63.2%	35.3%	6.7%	37.3%
Total		N.	19	17	15	51
		%	100%	100%	100%	100%

Pearson Chi-Square 11.486(a), DF=2, Sig.=0.003

It was found that a high proportion of teachers of the Humanities subjects did not use computers while a high proportion of teachers of the Mathematics and Science subjects did use computers. The example of the findings from Singore is typical and is presented in Table 2.

Table 2: The relationship between Singore teachers' subject areas and whether or not they have used a computer (n=20).

			Teaching Subject(s)						Total
			Modern Languages	Human-ities	Business Studies	Maths/ Maths and Physics or Chemistry	Biology/ Biology and Agriculture	Tech-nical	
Have you ever used a computer?	Yes	N.	2	1	2	5	2	1	13
		%	50%	33.3%	66.7%	83.3%	66.7%	100%	65%
	No	N.	2	2	1	1	1	0	7
		%	50%	66.7%	33.3%	16.7%	33.3%	0%	35%
Total		N.	4	3	3	6	3	1	20
		%	100%	100%	100%	100%	100%	100%	100%

Pearson Chi-Square 3.15(a), DF=5, Sig.=0.677

Only two (10%) of the staff interviewed in St Patrick's said they had an e-mail address, and only three (15%) had ever used the Internet. The figures were better for Singore where 30% of the staff said they had e-mail addresses and 50% had used the Internet (in public Internet Cafés). Teachers appeared not to use the Internet to search for information related to their teaching subject areas although around half in both schools indicated awareness of this possibility.

Parents' Perspectives

Of the sample of parents of secondary school students interviewed (n=10), only one had ever used a computer. Despite this, seven out of ten felt that computers were *extremely important* in the lives of their children, while the remainder said they were *very important*. This reflects the significant levels of enthusiasm among parents for ICT. Parents, however, were, for the most part, unable to respond to the question as to the ways in which computers could help their children. Two parents mentioned improved career opportunities, but most admitted they did not know enough about computers to be able to say exactly what benefits they might herald for their children.

Impact of Exposure to ICT in Schools

As an indicator of improving their practices as a result of exposure to ICT in schools, students were asked if they had ever used a computer to assist them with studies in another subject area. The results ranged from only one third of Form One students in Singore (n=6) who claimed ever to have used a computer to assist them in another subject to 80% in Form Two (n=5) and 100% of the Form Three students (n=3). However, a broadly similar trend was found in St. Patrick's where only 10% of the Form Ones and Twos (n=10) claimed ever to have used a computer to work on another subject, rising to 80% of students in Form Three and Four (n=10).

These figures relate to improving practices among students as they demonstrate increasing evidence of the practical application of ICT skills learned as students' years of exposure increase. They are particularly encouraging when one considers that only 5% of current students surveyed in St. Patrick's said that any other teacher (apart from the Computer teacher) had ever used computers to teach their subject. Although this figure was considerably higher for Singore (at 21%), the figures show that, on the whole, teachers did not give students a good example as to how computer technology may have a practical application in diverse subject areas.

The research shed light on some of the tangible benefits to students of exposure to ICT in secondary schools. Some were able to secure short-term work in the area of IT, while all past pupils claimed to have needed a computer for some work, study or leisure-related activity since leaving school. It was clear that exposure to computers in schools had a considerable impact on the career choices of former students, with many opting for further studies in the area of IT. Some 38% of respondents listed Computer Engineer as one of their three most preferred jobs. What was surprising was the number of students who opted specifically for "Computer Engineer". This seems to illustrate a rather poor foundation in secondary school in the area of career opportunities in ICT. The Computer Studies syllabus recommends four lessons in Form Four to deal with descriptions of careers in ICT e.g. Computer Operators, Programmers, Software Engineers, Database Administrators, Computer Technicians, Web Designers, Systems Analysts, etc. (KIE 2002, p.42). The responses from the students in this survey, while certainly suggesting a high level of interest in careers in ICT, also suggest low levels of awareness of the various career options in the field.

CONCLUSIONS

This research highlighted the complete dependency on licensed software and standard Microsoft® applications such as MS Word® and MS Excel®, and the absence of any educational software. This is in spite of the commitment of the government of Kenya that the development and deployment of Open Source software for public and private sector would be encouraged (Kenya Government, 2004b, p.14).

Computers set aside for the exclusive use of teachers were not found in any secondary school surveyed, highlighting the low priority given to this by school managers, confirmed in the findings of previous research that "the first computer sits in the Principal's office, the second at the secretary's desk or the bursar's and the third goes to the computer laboratory" (Aguyo, 2004, p.155). This could go some way towards accounting for another significant finding in this research, namely that many teachers were found not to be making use of the ICT facilities in their schools.

Some schools had acquired such facilities over ten years ago, yet 35-40% of teachers, representing, in particular, those longest in the profession, and those teaching humanities and language subjects, were found not to be exploiting the potential of computer technology to enhance teaching and learning in their subject areas.

The involvement of private companies in the provision of computer equipment, software and/or personnel to schools was concluded, from the findings of this study, to be poor value for money. The contract entered into by Singore required the school to pay 60% of the total cost of the hardware up front, and then continue to pay approximately 20% of the total value of the hardware on an annual basis. The school was locked into this arrangement for five years and prohibited from utilising the facility for its own income-generating activities such as printing and computer training. Clearly, any arrangement by which a private company recoups its full costs potentially within less than two years and then begins to turn a profit at the school's expense should be discouraged.

It was found elsewhere that the expenditure incurred associated with the donation of computers could sometimes be equivalent to the purchase of new machines. The case was presented of the donation of laptops which attracted importation duty, the loading of licensed software and, in some cases reconditioning and the replacement of spare parts.

This research exposed the failure of former students fully to exploit the resource of the Internet as a source of information on careers, job opportunities and college and training courses. This is an obvious consequence of the lack of Internet access in schools, and the absence of any meaningful introduction to the potential of the Internet in the course of computer training. Only one respondent said he had used the Internet to find out about a college course abroad, and seemed determined to pursue the lead. While information on courses within Kenya on the Internet is not up to the standard of foreign universities and colleges, relevant information is nevertheless available, especially on careers.

Immediate reform in the telecommunications sector is necessary to hasten the rollout of computer technology in educational institutions in Kenya. In the areas of Internet connectivity, importation duties, rural electrification, software provision and financial support, much work remains to be done by Government, the private sector and development partners in order to create an enabling environment for ICT in education. At school level, some of the burning issues which arose were: the need for staff training, mainstreaming of ICT across the curriculum, additional computer equipment for staff and students and the development of relevant software and Internet access. Among the recommendations made specifically for development partners include a commitment

to local ownership, emphasis on ICT in girls' schools, staff training, Internet access and the provision of equipment and software.

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