FACTORS INFLUENCING THE EFFECTIVE USE OF ICT IN TEACHING AND LEARNING SCIENCE CURRICULUM IN KENYAN SECONDARY SCHOOLS: THE CASE OF CYBER AND NEPAD e - SCHOOLS

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university

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This Thesis has been submitted for examination with our approval as the University Supervisors.

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DEDICATION

This thesis is dedicated to my wife, children and Poosy for their encouragement and patience while waiting for me to conclude this immense work. Their prayers were the force that fuelled my determination to accomplish this task. To my family I say: "Thank you for bearing with me during my studies".

ABSTRACT

This study set out to investigate the factors that influence the use of Information and Communication Technology (ICT) in the curriculum designed for teaching and learning science in Kenyan secondary schools. The sample for this investigation was drawn from Cyber Schools Technology Solution (CSTS) and New Partnership for Africa Development (NEPAD) e-Schools in Kenya. It is pertinent to note that educational systems worldwide are vigorously pursuing the integration of ICT as a means of keeping abreast with the rapid technological changes associated with a knowledge-based economy. The education system in Kenya is no exception to these emerging pedagogical changes, which have subsequently prompted the government to introduce several e-initiatives related to the integration of ICT in learning and teaching. In spite of massive spending on education by the Government of Kenya, there is a serious and widening gap between current schooling outcomes and the skills required for effective participation in global workplaces. The reality in the classroom falls short of the aspirations of those advocating for the use of ICT in teaching and learning in schools especially in NEPAD e-schools and Cyber e-schools.

A considerable amount of research has been undertaken to investigate the impact of ICT on society as a whole and on educational systems in particular. However, these investigations have generally been confined to Western contexts. In view of this bias, this study sought to investigate the impact of the school environment in the integration of ICT, access to ICT infrastructure, teachers' and learners' training in ICT skills and the role of infrastructure providers New Partnership for Africa Development (NEPAD and Cyber School Technology Solutions Limited (CSTS) in secondary e-schools in Kenya. The primary objective was to examine the ways in which ICT integration has impacted on the teaching and learning of science subjects as well as to establish the current level of ICT integration. This was carried out in order to determine factors that influence its effective use in teaching and learning science subjects.

A descriptive survey was employed using an *ex-post facto* design. This entailed collecting data using a mixed mode approach, involving a combination of qualitative and quantitative techniques. The investigation was conducted in twelve secondary schools which were located in the eight provinces of Kenya. Six of the schools sampled are currently participating in the Cyber School Technology Solution ICT programme, while the remaining schools are NEPAD e-school demonstration schools in Kenya. Two standard questionnaires were distributed to a total of 1247 students and 44 teachers. The data elicitation techniques consisted mainly of interviews, observations, site visits and analysis of documents relating to the mentioned programmes.

The findings of this investigation were that learners and teachers in both NEPAD and Cyber e-schools were not adequately trained on the use of ICT in the teaching and learning science subjects. Training in basic technical ICT skills was also found to be inadequate. This is primarily due to the fact that the existing pedagogy, as well as the existing information resources in NEPAD and Cyber e-schools do not support the effective use of ICT in teaching science subjects. Moreover, the investigation established

that even in cases where teachers had received some ICT training, not much time was allocated for the teachers to apply and implement the ICT skills they had gained into their teaching methodology. The teachers also lacked pertinent information and skills necessary to enable them to access relevant scientific information from the Internet. A further hindrance was caused by the poor Internet connectivity in a number of e-schools, whereas others lacked Internet connection all together. Furthermore, most schools did not have the required multimedia equipment. High costs were also observed to be an inhibiting factor in integrating ICT into the science teaching and learning curriculum in the NEPAD and Cyber e-schools. Based on these findings, the ICT projects in schools will be unsustainable if the cost factor is not reviewed and resolved.

Other factors that had a significant influence on the use of ICT integration in teaching and learning science subjects included technical and pedagogical ICT-competence, attendance at ICT-related professional development courses, location of the schools, availability of computer laboratories and access to Internet services and power supply. In addition, the number of working computers, availability of file servers, students computer sharing ratio, ICT skills, duration of ICT training, and pedagogical skills were also significantly and positively correlated to the use of ICT in teaching and learning science subjects. Of all the personal characteristics of science teachers, pedagogical ICT-skills were observed to be the best positive predictor of the teachers' pedagogical adoption of ICT. This research finding triangulated well with the observation that teachers were more willing to attend pedagogical than technical professional-development activities with regard to the use of ICT.

The conclusion of this investigation is that the use of ICT in teaching science subjects at both NEPAD and Cyber e-schools has had a limited impact on science education in the schools. This is mainly because teachers in these schools did not have time outside their normal working schedules and the necessary technical skills to repair non-functional computers. In a number of cases, there was no Internet connection and the support provided from the school administration as well as from the ICT infrastructure providers (NEPAD and CSTS) was minimal. Nevertheless, modern insights into the use of ICT in science education were gained and new approaches to science education developed in the e-schools, some of which provided new challenges in teaching methodology. Furthermore, both the teachers and learners attempted to utilize a few emerging methods for teaching subjects during the NEPAD and Cyber e-schools projects.

This study recommends that teachers and learners need to be supported through face-to face training in the ICT skills necessary for teaching and learning. This will enable them to develop the required confidence needed to integrate ICT skills in a classroom environment. In this respect, this study recommends the development of a National ICT training strategy for them. It is also pertinent that accessibility to good quality ICT infrastructure is developed to enable teachers enrol for online distance courses in ICT integration in learning and teaching science subjects. Moreover, a National policy on refurbished computers will be necessary to avoid the dumping of obsolete computers into schools. Finally, clear policy guidelines are required to guide the strategic incorporation of ICT into the teaching and learning curricula used in Kenyan schools.

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Disclaimer:

The Views expressed in this thesis are those of the Author – Peter Njenga Keiyoro and do not reflect the official policy or position of The University of Nairobi, individuals or groups of persons who provided me with any form of assistance during this study. This is my original work and I remain fully responsible for any claim that may arise from this work.

Peter Njenga Keiyoro: Signature ____________ Date 18/9/10

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

AfDB	Africa Development Bank
CAL	Computer Assisted Learning
CD-ROM	Compact Disc – Read only Memory – drive
CMI	Computer Managed Instruction
CSTS	Cyber e- School Technology Solutions
DEOS	District Educational Officers
DfEE	Department for Education and Employment
GOK	Government of Kenya
ICT	Information and Communication Technologies
ILS	Integrated Learning Systems
ISP	Internet Service Providers
IT	Information technology
KCSE	Kenya Certificate of Secondary Education
KESSP	Kenya Education Sector Support Programme
MOEST	Ministry of Education
NEPAD	New Partnership for Africa's Development
NGO	None Governmental Organisations
RAM	Random Accessing Memory
NGO	None Governmental Organisations
PC	Personal Computer
SPSS	Statistical Package For Social Science
TV	Television

Definition of significant terms used in the Study

Computer Assisted Learning (CAL): Covers subject-specific software, which provides students with instruction in the form of a tutorial-style programme on the material being covered.

Cyber School Technology Solutions (CSTS) : Cyber School Technology Solutions is a leading provider of digital science materials technology for schools, colleges, universities, and the Government of Kenya.

Cyber e-School: This refers to schools that implemented digital science projects through CSTS.

Information, and Communication Technology (ICT): Typically used to refer to computer technologies but used for learning and teaching strictly speaking should also include other technologies used for the collection, storage, manipulation and communication of information. In some places the term IT (Information Technology) is used.

Integrated Learning Systems (ILS): Integrated Learning Systems – covers programmes that provide students with individualized instruction in the form of an interactive tutorial system.

Applications: Refer to a type of software such as a word processor or generally to the use of computers in a particular situation.

Computer: Electronic machine, operated under the control of instructions stored in its own memory that can accept data (input), manipulate data according to specified rules (process), produce results (output) and store the results for future use.

Computer Literacy: Used in reference to the knowledge, skills and attitudes, which enable a person to use computer technology to for their individual benefits as well as to benefit others in relation to specific tasks they wish to accomplish.

Curriculum: The term comes from Latin meaning to run a racecourse. Its meaning in education has come to mean a combination of the learning outcomes, pedagogy, and content that students are to address. The Pennsylvania State Board of Education defines it as "a series of planned instruction that is co-coordinated and articulated in a manner designed to result in the achievement by students of specific knowledge and skills and the application of this knowledge".

E-mail (electronic mail): Text messages and computer files exchanged through computer communication, via Internet or intranet networks.

Hardware: The tangible components of computers including processors, input, output, communications and memory.

Internet connectivity: The international network of networks of computers using common protocols such as TCP/IP.

Learning Outcome: That which students may demonstrate from what they have learned. In Curriculum Framework, these are described as sets of outcomes associated with areas of learning.

Online: Refers to connection to host/server computers as found on the Internet

Pedagogy: A strict dictionary definition would state that pedagogy concerns the science of teaching children. It concerns what teachers do when they interact with children to support their learning. Most educators would consider that pedagogy encompasses the beliefs and actions of teachers including their teaching strategies, the organization of learning experiences and of the learning environment generally.

Science: Includes one or several of the school science subjects, i.e. integrated/general science, science, biology, chemistry, physics and mathematics

Software: The set of instructions and data used by computers, sometimes referred to as computer programmes.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The potential for Information and Communication Technology (ICT) to support Open and Distance Learning (ODL) and sustain students learning programmes is immense. E-learning is an example of use of ICT supported teaching and learning processes. The use of e-learning or online instructions in educational institutions is gaining momentum in Kenya and other developing countries (Omwenga et al, 2004). It has been argued that use of ICT has much to offer in overcoming existing constraints such as distance, time and age within Open and Distance Learning systems in Kenya (Bowa, 2008) and more so, in teaching science curriculum. Despite considerable growth in the numbers of computers and the emphasis on learning ICT skills in Kenyan schools recently, there has been little evaluation of ICT usefulness and effectiveness in teaching and learning science curriculum in open, distance learning systems or classroom environments.

A number of researchers including Iding et al (2002): Shamath et al (2004) and Romeo (2006) assert that the use of Information and Communication Technology (ICT) in teaching and learning can help students become more knowledgeable. Furthermore, it also reduces the amount of time spent on direct instruction of learners by teachers and in so doing, gives teachers an opportunity to help students who have special learning needs. The use of ICT in the classroom is essential in providing students with a chance to learn how to operate in an information age. Yelland (2001) argues that traditional classrooms do not offer learners suitable learning environments necessary for preparing them to be productive in the workplaces of today's society. In her view, institutions that do not use new technologies in teaching and learning cannot claim to prepare their learners for life in the twenty-first century. This argument is supported by Grimus (2000), who stated that the use of ICT in school-based teaching and learning helps the learners get prepared to engage in future developments based on proper understanding. Bransford et al (2000) also notes that current theories on learning provide an important baseline for the use of ICT to enable students and teachers develop the competencies needed for the twenty-first century. Consequently, acquisition of ICT skills can play an important role in learning and teaching processes. Bransford et al. (2000) reiterates this with the assertion that ICT has great potential to enhance student academic achievement and teaching methods.

Technology can also play a big part in supporting face-to-face teaching and learning in the classroom environment (Wong et al., 2006). These new technologies can help teachers enhance their pedagogical practice and consequently assist students in their learning process. According to Grabe and Grabe (2007), technologies can play an important role in enabling students gain skills and motivation in the process of acquiring knowledge. It can therefore be argued that, students who are proficient in ICT skills are able to search for information, present data and complete many learning tasks.

Four factors have been identified as playing a significant role in influencing the use of ICT skills in learning and teaching opportunities in school environments (Becta, 2003). These are the availability of ICT resources, training in ICT skills, school leadership and general teaching methodologies. Gakuu (2009) emphasizes that the success of the integration of ICT in teaching and learning varies from curriculum to curriculum, place to place and class to class, depending on the ways in which it is applied. There are also some areas in learning where the Integration of ICT in education has been shown to have a positive impact on teaching and learning science curriculum (Yidana, 2009). The power of ICT to engage and challenge students in exactly the same way that science teachers do is well-documented (Scaife and Wellington, 1993).

In order to overcome the barriers associated with the integration of ICT in learning and teaching, a pedagogical shift is required (Linn, 1999: Baggott la Velle et al, 2001). A case in point is that successful use of ICT can produce change in pedagogical practice, although whether this enhances student's learning is still controversial as exemplified in this investigation. This was important because the pedagogical approach adopted in traditional classes has been shown to have a major influence on the cognitive achievements of students (Harkin et al, 1997). Cox (2000) gave examples of this, including explaining the place of the computer in the teaching and learning relationship. She refers to this relationship in terms of "the computer as a third person" in teaching environments. Evidence from research carried out suggests that teachers assume a more managerial and facilitating role when they use their ICT skills in teaching contrary to being the sole providers of knowledge (Underwood, 1988). Clearly, the teacher's competence and confidence in using ICT in teaching is an important factor in the success of learning. This research investigated the role of this factor in teaching science curriculum.

An understanding of how ICT supports and enhances the learning tasks in science curriculum is a vital pedagogic aspect and was investigated in this study. Evidence from related literature suggests that student's struggle to make sense of their learning tasks when they are given sufficient information and guidance by their teachers during a teaching and learning process (Reinen, 1996). These observations highlight the importance of effectively embedding use of ICT skills in teaching and learning in a science curriculum. The use of ICT in teaching has other potential educational benefits such as being a tool for enhancing science learning in schools (Skinner and Preece, 2003). Such educational benefits include attainment of abilities such as data capture, multimedia software for simulation, publishing, presentation, digital recording, computer projection technology and use of computer-controlled microscopes (Osborne and Hennessy, 2003).

Although the use of educational technologies in the classroom has many advantages, current research suggests that it is not appropriate to simply assume that the use of ICT will necessarily transform science education (Osborne and Hennessy, 2003). As previously mentioned, there are several factors that influence both students' and teachers' use of ICT in teaching and learning science curriculum in any given education atmosphere. This study explored those factors that impede or enhance the effective use ICT in teaching and learning science subjects in Cyber and NEPAD e-schools in Kenya.

1.1.1 Global Perspective in Use of ICT in Teaching and Learning

According to the World Bank (1999), ICT consists of the hardware, software, networks and media for the collection, storage, processing, transmission and presentation of information. The use of ICT in open and distance learning especially in online learning is fast gaining prominence in the world today. Utilization of ICT in teaching and learning falls into several categories that include constructing knowledge, problem solving through the Internet, email, use of CD-ROMs, databases, video-conferencing, aiding of explanation of concepts and communicating ideas using power point and desktop publishing (World Conference on Education for All , 2002).

The use of ICT in teaching and learning is therefore a relevant and functional way of providing education to learners that will assist them to acquire the required capacity for learning and their personal work. This is because there are very few jobs that do not require the use of ICT skills in technology, collaboration and teamwork. All of these useful work aspects are achievable through teaching and learning with ICT.

The use of ICT in learning and teaching fundamentally changes the way we live, learn and work. It has been found that, ICT can also promote students' intellectual qualities through high order thinking, problem solving, improved communication skills and deep understanding of learning concepts (World Bank, 2006). Moreover, ICT promotes and supports interactive teaching and learning environments, create broader learning communities and provide learning tools for students, including those with special needs (Trinidad et al., 2001: World Bank, 2002). Computer-generated graphics or animations are used to illustrate relationships of all kinds during learning, especially dynamic processes that cannot be illustrated by individual pictures (Franke, 1985). The interest created through the use of ICT in learning may also help students to improve school attendance levels since it tends to provide new and more motivating learning environments.

Integrating ICT in education initiatives is likely to successfully contribute to the Millennium Development Goals by increasing access through open and distance or online learning (Sutton, 2006). This is because it provides a knowledge network for students, meeting teacher-training needs, increasing the availability of learning materials and enhancing the quality of administrative activities. Other identified advantages of ICT use in learning and teaching include removal of age, distance, time constraints from any learning process and provides effective library resources (Adekomi, 2006). The use of ICT makes learning interactive and creates learner centred teaching approach possible (Trinidad et al., 2001: Carter, 2002). In addition, the integration of ICT into teaching methodology energizes the students (World Bank, 2002) and encourages deeper understanding about data collection, saves time on measuring and recording and helps in data analysis (Bryant et al., 2003).

For effective use of ICT in learning, the pedagogical approaches currently used by teachers will need to change from teacher-based instruction to learner-based learning. ICT provides these opportunities. However, in order for this to be achieved, teachers will need to undergo formal training in ICT usage to help them integrate technology into their pedagogical approaches. This study did investigate the effects of suitable training on pedagogical skills and use of ICT skills in teaching and learning science subjects in NEPAD and Cyber e-schools in Kenya. According to Duffy and Cunnigham (1999), teachers need to have access to professional development programmes to enable them to master skills in use of ICT in classrooms. New technologies can help teachers enhance their pedagogical practice and hence assist students in their learning process. The competence of teachers and their confidence in using ICT skills is an important factor in making learning successful. Consequently, a comprehensive understanding of how ICT supports and enhances learning tasks in science curriculum is vital as evidenced in this investigation. According to Olsen, 1992 and Reinen, 1996, students struggle to make sense of their learning tasks when given insufficient information and guidance by their teachers during the teaching process. This observation serves to highlight the importance of embedding the use of ICT in teaching and learning science in schools.

1.1.2 Use of ICT in teaching and learning science curriculum

Throughout the 1990s, a series of research findings including those provided by Crook (1991) and Watson et al (1993) highlight the potential benefits of integrating ICT when teaching the science curriculum. A review by Crook (1991), on ICT use in the curriculum, including science, showed that pupils using ICT took greater responsibility for their own learning. Watson et al., (1993) investigated the impact of ICT on student's achievements in science (amongst other subjects) and provided evidence that student's spent longer time on learning tasks when using computers in learning. Changes in student's attitudes and motivation for learning have also been found, in biology lessons for instance. The findings were that when students used an artificial intelligence tutor, there was clear evidence of increased enjoyment and interest (Schofield et al., 1993). Also Morrison et al. (1993), found an enhanced sense of achievement in learning amongst students using laptops for a year across the curriculum, including science subjects. Friedler and Ncfarkabce (1997), found a clear evidence of enhanced learning with data logging.

However, the highlighted studies were individualized investigations and the results were not replicated in classroom practices. Consequently, through the 1990s use of ICT applications in teaching science subjects remained patchy, although there was good evidence that many teachers used it for personal and professional purposes (Goldstein, 1997). A range of school circumstances and technical difficulties made ICT marginal to science teaching activities (DFE, 1995: DfEE, 1998). McKinsey (1997) demonstrates that only 5% of science teachers regularly used ICT in their lessons compared with 34% of mathematics teachers. Science teachers cited many reasons for not using ICT in teaching and learning science subjects. Such reasons included generic software provided with network, lack of relationship between ICT and science curriculum, need for all students to work on computers all the time in a science lesson, systems problems that resulted in time wastage during a science lesson and lack of relevance of ICT to science curriculum. The present investigation explored the possible links between teacher's use of ICT in teaching science curriculum and their training in ICT skills, the school environment, access to ICT infrastructure and the role of infrastructure providers.

1.1.3 The Current ICT infrastructure situation in Kenya

Kenya lags behind in information technology and experiences many of the ICT related problems typical of sub Sahara Africa enumerated by Langmia (2006). Generally, the telecommunications infrastructural developments and growth of fixed telephone network throughout Kenya has been below expectations. The Central Bureau of Statistics (2006) indicates that, fixed line tele-density was 1.02% (number of fixed lines per one hundred people) during the year 2003 which increased to 252,886 in 2008 showing slow growth (http://www.cck.go.ke 2010). This has actually deteriorated since then due to steady population increase in the absence of equivalent infrastructural development. Most of these fixed line subscribers are concentrated in urban areas and account for 94% of the fixed lines while 6% are in rural areas. 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). This has since increased to 16,233,833 in December 2008 showing increase of 11.9% (http://www.cck.go.ke 2010)

The 2007 estimates indicate that Kenya's Internet penetration consists of 4.4%, which includes more than one thousand cyber cafes, computer penetration of 2%, television penetration of 60%, radio penetration of 90%, and mobile phone penetration of 16% (Siele, 2007). This increased to 3,359,552 in December 2008 showing an increase rate of 10.4% http://www.cck.go.ke 2010). Unfortunately, these statistics show that Kenya is lagging behind many countries in these technological indicators.

Kenya has 4,506 secondary schools countrywide of which 85% of them are located in rural areas. Only 65% (2,600) have electrical power supply while 1,400 schools totally lack power supply. Approximately, 750 Secondary Schools have Computers (approximately ten PCs each) and few have connection to Internet (Field Visit Infrastructure Report Eastern Team MOEST). Since the year 2003, secondary school enrolment has grown by 18.3% from 882,390 students in 2003 to 1,043,467 students in 2006. In 2008, the number of candidates admitted to form one was 395,000, which represents a transition rate of 60%. The number continues to increase with new schools are opened and secondary school education having been declared free (Website: www.education.go.ke, accessed in February 2008). The Government intends to sustain and enhance the current growth in enrolment in order to achieve the target of 70% transition rate by the year 2009.

1.1.4 ICT use in the Kenyan Education System

In Kenya, science teaching at the various levels retains the old conservative approach with the teacher, in most cases, acting as the repertoire of knowledge and the students the dominant recipient. A case in point is that teachers over-rely on textbooks and only have occasional demonstrations and experimentation (Muriithi, 2005). The author observed that, on average classroom situation, one finds a teacher at the blackboard jotting down important facts, students copying all that is written and spit them out on an examination day.

In Africa, Latin America and other poor countries, majority of the teachers not only lack adequate hardware and software, but also reliable Internet access (World Bank, 2006). These are significant barriers to using computer-assisted instructions in schools. With the increased momentum of ICT revolution sweeping across the world, there is need for teaching and learning system in Kenya to change such that, computers become part of learning and teaching classroom environments in schools. A diagnostic study such as the present one was motivated by the need to help establish factors that could hinder or enhance the country's move in this direction. With globalization, a bridge is required across the digital divide in the teaching and learning processes between technologically rich developed countries and technologically poor developing countries like Kenya.

Through the Ministry of Education, the Government of Kenya launched a multi-million Information and Communication Technology Trust Fund. In his speech, at a graduation ceremony for ICT graduands at the Kenya Institute of Education on November 28, 2004, the Minister for Education (MOEST) mentioned that, the government was committed to providing 2500 of the 3500 public secondary schools in Kenya with computers by the year 2008. The Ministry's intention was to embark on the ambitious programme of connecting all primary and secondary schools to the Internet in ten years. Consequently, six schools were earmarked to benefit from a pilot programme officially launched on September 29th 2005 (Daily Nation, July 6, 2005).

Currently, there are indications that the country is committed to integrating ICT into its education system and is investing in access, equipment and ICT skills development. The Government of Kenya's commitment to the integration of ICT in education has also been indicated through development of the a number of strategies. These includes the development of Kenya Education Sector Support Programme (KESSP) in 2005 in which ICT featured as one of the prioritized areas with an aim of integrating ICT in teaching and learning process. This was followed by development of National policy for ICT – 2006. The policy has a section that sets out objectives and strategies for use of ICT in education. Lastly, in 2006 the Ministry introduced National ICT strategy for Education and Training for the education sector.

Various organizations within the Private sector have also participated in the introduction of ICT in schools. One such non-governmental organization is Computer for Schools – Kenya, whose mission is to provide Kenya's youth with access to modern ICT skills through donation of computers to Kenyan Public Secondary Schools. Over three hundred secondary schools have been supplied with computers so far. Kenya Schoolnet is also another private organization that has taken the initiative to start a Training of Trainers programme in ICT skills. Barclays Bank of Kenya has also donated computers to schools. In 2004 alone, The Bank donated twenty computers to public secondary schools in Nairobi. Other organizations that have participated in integration of ICT in educational institutions in Kenya include New Partnership for Africa Development (NEPAD) and Cyber Schools Technology Solution Company (CSTS). The schools that participated in NEPAD and CSTS programmes formed the focus of this study.

1.1.5 Profile of NEPAD e-Schools

The New Partnership for Africa Development (NEPAD) recognized the significance of Information and Communication Technologies (ICTs) on all aspects of national life. In this regard, e-Africa Commission was created in 2001 and adopted as an ICT Task Team in 2002. In March 2003, the NEPAD Heads of State and Government implementation Committee (HSGIC) adopted the NEPAD e-schools initiative as a priority undertaking. This was aimed at equipping African young graduates from African schools with ICT skills that would enable them participate effectively in the global information society. The NEPAD e-schools initiative led by NEPAD e-Africa Commission also aimed at developing over 600,000 primary and secondary schools in Africa into NEPAD e-schools. The schools were to be equipped within a period of ten years with the necessary and appropriate ICT infrastructure including access to Internet and digital content. School managers and teachers were also to be provided with appropriate ICT skills to facilitate the integration of ICT in teaching and learning.

NEPAD e-schools initiative was to be implemented in three phases in 15 to 20 countries. The first phase constituted selecting demonstration schools for the purpose of providing the necessary experiences prior to a large-scale roll out in 2007/2008. Kenya was among the sixteen African countries that were selected for the e-schools demonstration programme. In this study, the NEPAD e-schools were assumed to have the necessary ICT infrastructure for use of ICT in teaching and learning science curriculum. The programme aimed at providing knowledge and real-life experience by implementing Information Communication Technologies (ICT) in schools across Africa that would form the model for a large-scale rollout. Consequently, the Government of Kenya entered into an agreement with Microsoft and Oracle for the supply of computers to the six e-schools. All of the six schools (NEPAD e-schools) in Kenya were selected for this study.

1.1.6 Profile of Cyber School Technology Solutions Limited. (CSTS)

The Cyber School Technology Solution (CSTS) Ltd is a leading company that provides education technology to schools, colleges and universities by availing digital science software. The company makes digital science materials accessible to secondary schools aimed at improving teaching of science curriculum in Kenya. Currently, applications for Physics, Mathematics, Biology and Chemistry are in use and are aligned to the country's specific science curriculum. The CSTS supplied digital science learning materials to selected schools in Kenya depending on their ability to purchase the materials. The schools were distributed throughout all the regions in the country. The digital science learning materials provided by CSTS were customized to meet the needs of Kenya Certificate of Secondary Education (KCSE) Syllabus.

The materials provided animated tutorials that help the student visualize dynamic science processes. The student can also perform experiments with visual animated equipment and procedure in a way similar to real laboratory experience. This virtual laboratory environment enabled students to understand even very complicated scientific principles in Physics, Mathematics, Chemistry and Biology subjects. The digital science materials incorporate interactive simulations, laboratory work place (virtual laboratory) and student observation. This innovative Virtual Laboratory contained all the experiments carried out in the secondary schools science curriculum. This has enabled schools with limited resources to carry out almost all science experiments in the curriculum. Since the experiments were carried out using the virtual Laboratory, potentially hazardous experiments did not pose any threat to the students.

The digital science nurtured students' curiosity, built analytic skills; interactive and provided tests and quizzes. This made science subjects fun to learn by introducing new teaching and learning resources in the subjects of Mathematics, Biology, Physics and Chemistry that animate and turn the subjects to life. Cyber School Technology Solutions (CSTS) has played a dominant role in providing software necessary for integration of ICT in teaching science curriculum in Kenyan secondary schools.

The Cyber School Technology Solutions (CSTS) also participated in equipping some schools with necessary hardware and software useful in teaching science subjects. The Cyber e-schools sampled for this study had received digital science software either for demonstration purposes or purchased the software from CSTS through their own initiative or the Ministry of Education financial support. The schools that participated in the CSTS project were referred to as Cyber e-Schools and were part of the target population in this study.

1.2 Statement of the Research Problem

Since the scale of investment in ICT has been massive, it is therefore important for researchers to evaluate the 'returns' beneficial to the Education sector in particular. There have been concerns raised within the Education sector about the ways in which ICT could be integrated in teaching and learning methodology to enhance the acquisition of knowledge and skills in Science. One general concern is that in Kenya, the impact of ICT in learning and teaching has been less than was originally anticipated. The reality in the classroom today falls short of the aspirations of those promoting the use of ICT in teaching and learning in schools, especially in NEPAD and Cyber e-schools. No previous research has been carried out on the effective use of computers in teaching and learning the Science curriculum within Kenyan education system. Furthermore, there had been no research in Kenya to investigate the issues raised by other researchers elsewhere in the world on the influence of the introduction of ICT in teaching and learning Science-based subjects. The need for research in this area became apparent to the researcher because of the traditional learning style attributed to Kenyan education system. Generally, the learning and teaching strategy used in the majority of Kenyan schools tends towards being largely examination- oriented, involving mainly "chalk and talk" methodology.

One survey research conducted by Muriithi (2005), focused on the integration of ICT in teaching and learning in Kenyan secondary schools. The findings of this investigation were that 75% of teachers in the sampled schools encourage learning by discovery method of teaching, with an almost similar number supporting learning through project work using ICT. Muriithi (2005) also noted that the majority of teachers (72%) felt that instructions using ICT should be built around problems with clear correct answers and around ideas that most students can grasp quickly. These findings have significant educational implications that support the need to assess factors that influence integration of ICT in teaching and learning, especially in science subjects in Kenyan secondary schools.

Surveys such as those undertaken by McKinsey et al. (1997), Goldstein (1997) and Poole (2002) identified a number of practical and educational hindrances that impede integration of ICT in teaching science subjects. One of these reasons is the lack of ICT infrastructure resources. According to McKinsey et al (1997) and Poole (2002), other problems that are encountered in integrating ICT in teaching and learning include: doubts held by teachers over the value of ICT in promoting learning of science lessons, clear rationale for the inclusion of ICT skills in teaching, lack of adequate training for teachers in ICT skills and its pedagogy and lack of time for teachers to plan for effective use of ICT in their lessons. Even though many of these problems are not unique to science; they were brought more sharply into focus in science subjects. This is because science subjects initially appeared to be the more natural domain for most ICT applications in teaching and learning. This study investigated whether these factors have an influence on the integration of ICT in teaching and learning science subjects in Cyber schools and NEPAD e-schools in Kenya.

The investigation sought to establish the relationship between the availability of ICT infrastructure and their utilization in the teaching and learning strategies used in the Science curriculum in the selected secondary schools. The research also focused on influence of ICT infrastructure providers (NEPAD and CSCTS), training in ICT skills among teachers and learners and the cumulative effects of the school environment on the use of ICT in learning and teaching science curriculum.

1.3. Purpose of the Study

The ultimate goal of this investigation was to identify the factors that influence the effective use of ICT facilities to support and deliver science content in Cyber and NEPAD e-schools. The study attempted to reveal the challenges and problems that these schools encountered in the process of implementing the ICT-based teaching and learning in the Science curriculum.

1.4 Objectives of the Study

This investigation focused on the factors that influence effective use of ICT in learning and teaching of science-based subjects in Cyber and NEPAD e-schools in Kenya.
The specific objectives of the study were to:

i. Establish how the school environment influences the use of ICT in teaching and learning science subjects.
ii. Determine how access to computers and other ICT infrastructure (including multimedia facilities) affect the use of ICT in the teaching and learning strategies used in the science curriculum.
iii. Verify how the training of teachers and learners in ICT skills influences the use of ICT in learning and teaching science subjects.
iv. Identify the role of ICT infrastructure providers in the use of ICT in teaching and learning science subjects in NEPAD and Cyber e-Schools.

1.5 Research questions

In order to focus on the objectives and the problem of this study the following research questions guided the investigation:

i. What are the specific environmental characteristics within the schools which have influenced the use of ICT in teaching science curriculum in the selected schools?

ii. How has the access to computers and other ICT infrastructure (including multimedia facilities) influenced the use of ICT in teaching the science curriculum?

iii. How has the training of teachers and learners in ICT skills influenced the use of ICT in teaching and learning science curriculum in the selected schools?

iv. How have the roles of ICT infrastructure providers influenced the effective use of ICT in teaching and learning science subjects in NEPAD and Cyber e-schools?

1.6 Hypotheses

To support the four objectives and research questions of this study, fifteen hypotheses were generated:

	Objectives:	**Hypotheses**
i - Objective one	To establish how the school environment influences the use of ICT in the teaching and learning science subjects.	H1a: The location of schools does not influence use of ICT in teaching science subjects H1b: Access to Internet services in schools does not influence use of ICT in teaching science subjects H1c: The power supply does not influence use of ICT in teaching and learning science subjects H1d: The physical environment inside the computer laboratories does not influence use of ICT in teaching and learning science subjects.
ii-Objective Two	To determine how access to computers and other ICT infrastructure (including multimedia facilities) affect the use of ICT in the teaching and learning strategies used in the science curriculum.	H2a: The number of working computers does not influence the use of ICT for teaching and learning science subjects H2b: The network connection does not influence use of ICT in teaching and learning science subjects H2c: The availability of file server does not influence use of ICT for teaching and learning science subjects H2d: The student's computer sharing ratio does not influence use of ICT in learning purposes.

iii-Objective Three	To verify how the training of teachers and learners in ICT skills influences the use of ICT in learning and teaching science subjects.	H3a: The level of ICT trainings teachers and learners received does not influence use of ICT in teaching science subjects in NEPAD and Cyber e-schools. H3b: The duration of ICT skills training does not influence the use of ICT in teaching and learning science subjects. H3c: The teacher's technical competence does not influence their use of ICT for teaching and learning science subjects. H3d: The training in pedagogical skills does not influence use of ICT for teaching and learning science subjects.
iv-Objective Four	To identify the role of ICT infrastructure providers in the use of ICT in teaching and learning science subjects in NEPAD and Cyber e-Schools.	H4a: The role of ICT infrastructure providers does nit influence use of ICT in teaching and learning science subjects H4b: The technical support received by the e-Schools does not influence use of ICT in teaching and learning science subjects.

1.7 Scope of the Study

The present study was limited to Cyber and NEPAD e-schools in Kenya. The investigation looked at the factors influencing effective use of ICT in teaching and learning science curriculum in Cyber and NEPAD e-schools. The teacher's confidence and competence in using any education technology are important factors in the success of learning and teaching systems. On the other hand, students make sense of their learning experiences when their teachers give them sufficient guidance. Since both students and teachers operate within a school environment in most cases, the physical facilities and administrative structure of the schools are crucial in the implementation of any new technology. Teachers and learners training in the use of the technology are vital. In order to elucidate factors associated with use of ICT in learning and teaching science curriculum, it was imperative to investigate how each of the following influenced utilization and implementation of ICT integration in the selected schools.

i. The influence of the school environment on the effective use of ICT in teaching and learning processes especially in science curriculum;
ii. Access to computers and other ICT facilities including multimedia in secondary schools;
iii. The training provided to teachers and learners to enable them integrate ICT into the school science curriculum;
iv. Challenges encountered by NEPAD and CSTS in implementing the integration of ICT in teaching and learning science curriculum in these schools.
v. These issues guided the investigation because under each of them, other relevant aspects that influence effective use of ICT were brought to focus. Consequently, this effectively dealt with the main aspects that affect effective integration of ICT in the learning and teaching methodology used in Kenyan schools. However, the successful integration of ICT in teaching and learning will vary from curriculum to curriculum, place to place and class to class, depending on the ways in which it is applied (Gakuu, 2009: Becta, 2003).

1.8 Justification of the Study

Education for new emerging societies requires ICT to facilitate large-scale learning needs for social and economic development. For the first time in history, information and scientific knowledge are not simply means of improving society only, but main products of the economy. Moreover, knowledge is a major asset and product of the society, upon which continued economic well-being and social development depend. ICT is in the mainstream of these developments.

ICT and information society are concerned with the creation, acquisition, sharing, dissemination, delivery, support and recognition of knowledge. ICT is the means for providing an access to and engaging in the continuous learning that becomes necessary for successful participation in the social and economic development.

ICT has become a critical tool for professional training; the sooner learners know how to use ICT, the easier they can find their way to capture the newest methods of data acquisition and its transformation to knowledge and skills. The scientific progress and the global spread of technologies developed in the most advanced countries of the world constitute one of the main arguments in favour of the leading role of science education in the 21st century.

The level of technological development is indicative of the economic power and living standards of a particular country. It also determines the place, the role of the country in the global community, the scope and the prospects of its economic and political integration with the rest of the world. Moreover, the level of development and utilization of modern technologies in different countries is determined not only by their material resources, but to a large extent, by the degree of society's ability to produce, absorb and apply new knowledge. These achievements in turn are closely linked with the level of science education. Currently, these processes are largely driven by information and communication technologies, where scientific knowledge and information increasingly determine new patterns of growth and creation of wealth and present possibilities of reducing poverty more effectively.

In Kenya today, a considerable emphasis has been placed on the importance of ICT in its education sector support programme. This has further been evidenced by the recent creation of the National ICT Strategy for Education and Training. Therefore, the government has taken steps to support implementation of the integration of ICT in teaching and learning. There are many other organizations including private institutions that are active in implementing and supporting integration of ICT in education. The factors that influence the use of ICT in teaching science curriculum have not been fully identified in Kenya and elsewhere in the world. Although the factors exist in both developing and developed economy, they differ in terms of importance from country to country and the degree to which they present themselves in a given country. Hence, it is important to focus on the factors that influence use of ICT in teaching science curriculum particularly in Kenyan secondary schools.

1. 9 Significance of the Study

The potential of ICT to change, support and sustain teaching and learning programmes is immense. This investigation provides a practical plan that can be applied to all NEPAD and Cyber schools. It entails tailoring a solution to suit individual school environments A possible solution to the problems of ICT usage in teaching the Science curriculum is a proposed plan of action that would allow teachers and learners to explore the possible use of digital science teaching and learning resources through the Internet. In addition, it will also encourage collaborative learning projects among schools in Kenya. This would provide a fertile ground for creation of virtual science-learning network designed in such a way that it meets the needs and concerns of Kenyan schools. Such needs include challenges encountered in teaching science curriculum in the country. For instance, there is a shortage of both science teachers as well as well equipped science laboratories. Specific factors that influence the integration of ICT in teaching and learning science curriculum were also identified during the investigation and solutions elucidated.

This investigation sought to identify the extent of ICT usage by teachers as well as the factors that promote and/or hinder the use of ICT in learning science subjects. It also identified variable factors essential for implementing valuable ICT-integrated programmes in schools. Consequently, this investigation exemplifies how the appropriate use of ICT in education can indeed contribute to a solution to the crisis of both quality and quantity of teachers in Kenya.

It is evident that traditional methods of teaching that base enrolment on physical facilities, is not able to meet the needs of the people in the current dynamic world. It is therefore of paramount importance that teachers in Kenya adopt alternative methods that have appeared with the emergence of new technologies that promote wider access to the traditional programs and also address the changing needs of the learner in the world today. In this context, this research is significant for this country since it will identify the extent to which new technologies are applied to enhance teaching and learning science subjects. The findings provide a baseline report against which policies as well as the planning for ICT integration in education and online learning in education institutions could be based.

As developing countries continue to rely on donor funds, investigations such as the present one will encourage participants and leaders to administer such projects for maximum benefits. The information generated herein provides useful literature for further studies on the issue of effective use of ICT in teaching and learning science subjects in Kenya and other developing countries.

1. 10 Assumptions of the Study

The Researcher made the following assumptions during the study:

i. The five years NEPAD e-schools initiative and two years of CSTS Cyber schools project – implementation period was adequate to get tangible outcome from the ICT project in the schools.

ii. The selected six NEPAD and six Cyber e-schools were expected to provide a true representation of all Kenyan secondary schools earmarked for rollout of ICT integration in learning and teaching strategies.

iii. All the NEPAD e-schools and sampled Cyber e-schools have the necessary ICT infrastructure required for integrating ICT in teaching science curriculum.

iv. The factors that were identified had an influence on learning and teaching science curriculum in the e-schools.

1.11 Organization of Thesis Report

The study has been organized into five chapters. Chapter One presents a general overview of the investigation. It includes a background to the Research Problem, the purpose and objectives of the research, research questions, a justification of study and the significance, scope and limitations of the study. Chapter Two is a review of the literature relating to issues raised by the study. Chapter Three entails a detailed description of the methodology used for the study. Chapter Four presents and analyses the collected data, based on the research objectives and hypotheses. Chapter Five discusses the research findings, summarizes these findings and provides conclusions and recommendations for areas of further research.

1.12 Summary

Chapter one has provided a general overview of the investigation. The Chapter provided an overview of the background to the study on the use of ICT in schools. Through the general overview, it became evident that the use of innovative technology in the classroom is essential in providing chances for students to learn how to operate in an information age. It is evident that institutions that do not adopt new technologies in teaching and learning in today's world cannot claim to prepare their learners for life in the twenty-first century. This is because students proficient in ICT are often able to search for information, present data and complete many learning tasks. Consequently, the introduction of new technology can help teachers enhance their pedagogical practice, which will ultimately assist students in their learning process. The chapter also described the global perspective concerning the use of ICT in teaching and learning. The current ICT infrastructure situation in Kenya, ICT use in the Kenyan education system, profile of NEPAD and of Cyber e-School has been discussed.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the relevant literature on the utilization of ICT in education especially in the areas of teaching and learning. It includes a review of literature on the use of ICT use in schools, education at global and local levels, and the factors influencing the use of ICT in the teaching and learning science curriculum. The review also includes an overview of the role of the school environment and its influence on the effective use of ICT in teaching and learning. The integration of ICT in teaching and learning and its access to ICT infrastructure in secondary schools is reviewed at the local and global levels since these are vital areas in the use of ICT in learning. The role of teacher training in ICT skills and its integration in science curriculum has also been extensively reviewed. Finally, literature on the responsibility of infrastructure providers is examined because of the significant role they play in ICT utilization and integration in schools in developing countries.

2.2 Utilization of Information and Communication Technology (ICT) In Education

A number of scholars have demonstrated why it is necessary to incorporate ICT into education systems (viz. Hawkridge et al, 2000: Tinsley and van Weert, 1995:Bigum, 1997 and World Bank, 1999). In particular, Hawkridge et al. (2000) proposes four rationales for the utilization of computers in schools. He categorizes them as social, vocational, pedagogical and catalytical. The social and vocational rationales point to the increased use of ICT in all spheres of human activity today. The pedagogical and catalytical rationale relates to the positive effects of the technology on students and teachers learning and teaching process.

According to Bigum (1997), using computers in schools stem from technological and socially determined points of view. His position is that computers drive the school system within which the computer is used. In his view, the change that occurs within the education system due to use of computers is a result of the effect of the technology. According to Tinsley and van Weert (1995), examples of technologically driven systems in schools include automating the school library services. Bigum (1997) in his social context point of view sees computers as neutral technical means of achieving a defined purpose in education. The contexts of utilizing computers as expressed by Hawkridge (2000) and Bigum (1997) underpin rationales for the implementation of the ICT programme in schools and its use as a teaching and learning tool.

Technology has developed in order to solve the problems associated with human needs in more productive ways. The inference is that if there is no problem to solve, then technology will not be developed or be adapted to suit particular needs. When this principle is applied to educational technology, it means that educators need to create and adopt technologies that will address the many pedagogical problems. It should be noted that, educators would not adopt a technology where there is no perceived need or productivity gain. This is what Lankshear and Snyder (2000) refer to as the 'workability' principle. Consequently, applications of computer technology to teaching and learning must deal with the question of exactly what educational problems need to be addressed. This question needs to be asked at all levels of decision-making, from the teacher planning a programme, to a school administrator purchasing hardware and software, to an educational system officer developing policy and strategic plans. At the teacher level, the question becomes, "am I satisfied with the teaching methodologies that I use in the classroom?" While teachers should never be completely satisfied with their pedagogical skills, the question they should really ask is whether what they use as a teaching tool has the potential to adequately prepare the students for a productive life in the society.

Many educators (National Centre for Vocational Education Research, 2002) and educational commentators (Murdoch, 2001) believe that what is offered in school classrooms in developed countries such as Australia is inadequate to match the needs of our society and the needs of individual students. Schank and Cleary (1995) argue that today's schools are organized around yesterday's ideas, yesterday's needs, and yesterday's resources. An increasing number of educators (Schlechty, 1997) propose that part of the solution is to provide better technology support for learning environments. Schank and Cleary (1995) argue that there is enough knowledge about learning process to support it with computer systems by using software that allows children to experience activities that have been impossible or difficult, and therefore avoided in the past.

At the school and education system levels, the question becomes whether the ICT resources available to the school are being efficiently utilized to provide the most effective educational opportunities to students. It becomes much more a question of productivity, a balance between inputs (resources) and outputs (learning outcomes).

Investing in computer technology may mean less investment in other resources (books, teachers, building. However, it is controversial whether or not the uses of computers as teaching tools actually provide better learning outcomes than the equivalent investment in other traditional learning resources. If they do, what level of investment in computers compared with other resources will provide the optimum output? Very few educators and educational commentators would advocate for no investment in computers, even if they were to be for literacy rationale. A few educators advocate an investment in education that supports all learning and teaching being conducted electronically, particularly online, often referred to as e-learning (Bonk, 2001).

At the political level the issue boils down to whether adequate investment is being made in education when compared with other services that our community requires. Providing computer technologies for schools has usually involved increases in investment in education that must be justified and that is usually done by quoting student: computer ratios. While research tends to have been somewhat inconclusive, other studies (Mann, et al., 1999) now demonstrate that greater investment in computer technology significantly improves learning. Mann, et al., (1999) found that use of computers in learning had average effect on learning of over 0.4 standard deviations, which was claimed to be more cost-effective than a reduction in class sizes. Education is central to the long-term well-being of any society as well as enhancing individual needs. Teachers and students need all the support they can get; hence the need to consider the potential of all available technologies. This study investigated the use of ICT in teaching and its adoption in order to address educational problems and/or improve productivity in education science.

Any discussion about the use of computer systems in schools is built upon an understanding of the link between schools, learning and computer technology. When the potential use of computers in schools was first mooted, the predominant conception was that, students would be 'taught' by computers as discussed by Mevarech and Light (1992). In a sense, it was considered that the computer would 'take over' the teacher's job in much the same way as a robot may take over a welder's job.

During the late 1970s and early 1980s, computers became more affordable to schools in developed world, permitting a rapid decrease in student-to-computer ratios. While tutorial software continued to be developed, other educational software was also developed (Chambers and Sprecher, 1984). This range of software was not based on the premise of teacher replacement, for example, simulation and modelling software. However, the major argument used to support the introduction of computer hardware and software into schools was concerned with the perceived need to increase the level of computer literacy of students and teachers (Carleer, 1984: Downes et al, 2001).

Towards the end of the 1980s and early 1990s, while the computer literacy rationale prevailed (Hannafin and Savenye, 1993), the major underlying principle for having computers in schools was concerned with the need to use computers to improve student learning (Welle-Strand, 1991). Broadly speaking, computer literacy is a component of Technology Education, which is distinct, but not necessarily separate from, using technologies such as computer systems to support learning and teaching processes. This was generally referred to as educational technology; and applies to a wide range of technologies including the use of blackboards and chalk, pencils, books, and slide-rules to television and recently computers.

Since the beginning of the 1990s, educators have been particularly concerned that very little of the potential of computers to support learning in schools seems to have been realized. This is despite the availability of computers in schools. Numerous studies have shown that few teachers use computers for learning (viz. Becker, et al., 1999: DeCorte, 1990: Plomp and Pelgrum, 1996). There are two major areas of application of ICT in the teaching and learning processes in schools. They consist of Computer Assisted Instruction (CAI) and Computer Managed Instruction (CMI). In addition, the use of Internet electronic mail, tele-conferencing, web site hosting, topic searching and file transfer have provided access to information that covers a wide range of topics and interests in research, science and technology.

In order to facilitate teaching and learning processes in the schools, CAI is not only an effective means of transforming knowledge, but can also be viewed as an extension of both the teacher and the chalkboard. In this case, topics covered in the syllabus or the curriculum is encoded in various computer programmes in a self-instructional mode that makes it easy for the students to use with minimal assistance. It has been argued (Heinecke et al, 1999) that, if one defines student learning as the retention of basic skills and content information as reflected in standard tests, then, evidence suggests that there is a positive relationship between computer-assisted instruction or computer-based learning and standardized tests. According to Hawkridge (2000), computers as pedagogical tools in Computer Assisted Learning (CAL), Computer Assisted Instruction (CAI) and ICT assisted learning environment (Yidana, 2009) offer advantages over conventional methods of teaching. This phenomenon has revolutionized education in advanced countries. Tinsley and van Weert (2001) concurs with Hawkridge (2000) that computers are useful tools for students' drill and practice, tutorial activities, guided discovery learning, building intellectual structures, data retrieval and data manipulation.

In view of the profound educational changes brought about by the integration of ICT into schools, in-service teacher training has taken a position of prime importance (van Weert 1995). This is more so because African education systems on the whole, devoid of learning resources, with the pedagogy largely characterized by a "chalk and talk" mode of imparting knowledge and skills (Stadler,1991: Bouwer, 1998: Hayman ,1999: Bot ,1999). Many teachers in Africa lack the expertise and means to deal effectively with the unique cognitive needs of learners. The learners are also faced with a critical lack of exposure to ICT learning experiences(Yidana,2009) which Western curricula require for cognitive development and skills of self- learning (Bouwer, 1998).

According to Johnson (1995) : Sultan and Woods (2009), certain teaching models are applicable in the utilization of computers in teaching and learning. These are; the constructivist, resource-based learning, authentic teaching and learning, project-oriented education, cognitive practices and collaborative learning. The resource-based method of teaching, for example, defines the position of a teacher as a facilitator in the learning process, rather than a source of knowledge (Karaliotas, 1998). The student team model has also been used mostly in school computer projects, with the teacher playing a dominant role (Arnall, 1995).

From an African perspective, O'Kennedy (1995) points out that in using the computer as a technological tool, teachers will act more as facilitator therefore giving purpose to the learning experiences. The implication of this is that much learning will be outside the teacher's sphere of influence. Lundall and Howell (2000) point out that when computers are used in schools for the first time it is normally done in a very rudimentary fashion, usually in the form of drill and practice and a development period follows during which teachers and students become familiar with the technology (Goldman et al.1999):

ICT has the potential to improve academic results in schools (Brown, 2002). This is chiefly due to ICT increasing the schools ability to prepare learners for the technology and knowledge-based society; increasing learners' access to education; supporting new pedagogy practices and improving school and classroom administration. ICT help to prepare learners by developing cognitive skills, life-long learning habits, ability to think critically, communicate and collaborate, access, evaluate and synthesize information (Castro, 2003: Cawthera, 2000). ICT also make learning material more authentic through simulations and providing analysis tools (Becta, 2004). ICT provide effective tools to administer schools (Cawthera, 2000). Using ICT, teachers are empowered to track and analyse learner's performance on a continuous basis (Cawthera, 2000), while reducing the time spent on class administration.

Computers, just like any other machine or tool, require specialized skills to operate and use effectively. Borman (1995) argues that computer science and programming is synonymous with computer literacy. This is equivalent to asserting that driving a motor vehicle should be preceded by a course in mechanical engineering or carpentry by a course in wood technology. The investigation relied on the simple definition of ICT literacy by Carbo (1997) and the techniques needed to use ICT effectively.

According to Holland (1999), new technology can be intimidating. However, computers are fairly easy to operate when one is equipped with the basic skills. Clyde (1997) points out that a person requires the knowledge and skills that are related to the hardware, the system, the software, the information source and the information itself in order to effectively use a computer. He categorizes these skills as hardware or equipment-related knowledge and skills. This includes the ability to use a mouse and keyboard, system knowledge and skills of network procedures. This is followed by application software skills which include word processing, electronic mail, Internet and knowledge associated with the use of the information system and search procedures as well as access techniques. Lastly, the knowledge and skills associated with using the information that is contained in e-sources or e-services were also categorized under ICT skills. This study investigated the extent to which both learners and teachers had been trained in use of computers to enable them effectively use ICT in learning and teaching science curriculum before and during introduction of NEPAD and Cyber e-school programmes in Kenya.

The need for technical computer skills has been emphasized by Clyde (1997) who proposes that ICT users need to acquire background information, knowledge and skills regarding the computer network procedures and Windows system. According to Lundall and Howell (2000), information infrastructures require constant maintenance and frequent upgrading. Technical personnel and teachers that look after the ICT programmes, including the workstations and file servers, require an understanding of the hardware and software. They need to know ways in which technology is going to be used in the short and medium terms. They will also need to know whether certain applications or software will run on a school's computer system. They should be able to advice on the optimal use of a network and sensible upgrades for long-term planning. These functions are extensive and could include user and network administrator functions, such as the creation of user identities, for example, login names and e-mail addresses and advising on licensing agreements. In order to address these requirements effectively, schools need to make a decision on the following: outsource some of the services e.g. technical personnel, share competent ICT staff with schools the locality and combine certain roles, e.g. technical support staff could also perform training of users. It is important for school managers to recognize that, ICT cannot be used in teaching and learning science subjects if there is lack of articulation between technical and educational functions. Also, cost considerations should include the fact that, technical staffs need constant upgrading on ICT skills.

Consequently, the effective implementation of ICT programmes in schools will require that teachers acquire basic ICT technical training skills to enable them operate the computer networks. Johnson and Eisenberg (1996) points out that in most schools, ICT technical skills were taught as isolated subjects and limited to students in choosing ICT related courses. Teachers and school administrators should recognize that ICT skills taught in isolation do not help students integrate ICT in learning (Johnson and Eisenberg, 1996). Instead, teaching of ICT skills must be integrated and in meaningful ways across the curriculum if the skills are going to be used in teaching and learning science subjects. This investigation deemed it necessary to assess the extent to which science teachers had been trained in basic computer technical skills. This aspect was essential for implementation and sustainability of NEPAD and Cyber e-schools ICT integration programmes.

Structural barriers have been found to exist in secondary schools in developing countries, which are likely to frustrate the utilization of ICT in teaching and learning science subjects. The categorization of "information-poor" nations and "information-rich" ones is a reality and is likely to continue as the gap between the former and the latter widens (Cawkell, 1998). According to Hall (1994), 95% of computers in the world are located in the developed world. Zulu (1994) outlines a number of factors, which act as barriers to the utilization of ICT in teaching and learning in developing countries, particularly Africa. This includes: lack of a good, reliable and adequate ICT infrastructural system (supply of electricity, a conducive computer environment and good telecommunications), non ICT literate population; lack of finance (foreign exchange); multiplicity of languages; lack of national ICT policies and rapid technological advances and changes.

Lack of ICT infrastructure is a major challenge, if developing countries, particularly those in Africa, are to become part of the global village. Menou (1993) indicates that, due to the high cost of information infrastructure, ICT services are notably concentrated in the major cities hence restricting instead of enhancing the flow of information. They are hence serving a few groups of people. Raseroka (1979) agrees with Menou (1993) that telecommunication infrastructure in Sub-Saharan Africa, excluding South Africa, is poorly developed. Telephone access in the region was as low as eight per thousand in Chad. One of the highest is thirty one per thousand in Botswana, with the major access points located in urban areas, mostly capital cities. Mbeki (1996) acknowledges that South Africa currently experiences skewed information infrastructure, which is very advanced in the cities, but totally lacking in some rural areas.

Africa lacks financial resources, technical expertise and information policies hence the continent, runs the risk of being turned into the dumping ground for obsolete technology from the developed world (Zulu, 1994). The challenges of lack of access and the fear that Africa may be turned into a dumping ground of obsolete equipment reinforce the need for studies of the ICT projects in schools as in this research. Developing countries, especially those in Africa, are also vulnerable when it comes to globalization and distance learning. This is because, majority have a poorly developed electronic environment. They also lack the finances to achieve inter-connectivity on their own and that computers in many instances are obtained as part of project funding through donor agencies. Inherent in the projects are the limited uses to which computers are put, as well as a limited skills base. Also, ICT infrastructure is selective with donor funding, with inherently questionable sustainability, and a cycle of dependency results, rather than the facilitation of creative partnerships. Many developing countries are not able to benefit from the lowering costs of technology because of their weakening domestic currencies (Raseroka, 1997).

2.3 The Global Context

Drawing primarily on ideas originating in Europe, Canada, the USA, Australia and New Zealand, there is an emerging consensus on the general set of principles that need to be in place for ICTs to be used effectively in teaching and learning (World Bank, 2002). Emphasis is frequently placed on the necessity for teachers and learners first to be trained in basic ICT skills. Consequently, in order for education system to reap the full benefits of use of ICTs in learning, it is essential that pre-service and in-service teachers have basic ICT skills and competences. Thus, the following four competencies need to be addressed: pedagogy, collaboration and networking, social issues and technical issues. In turn, four key themes are essential in any successful program on integration of ICT in learning and teaching: context and culture; access to ICT infrastructure; leadership and vision; school environment and the planning and management of change.

Such arguments build on the increasingly widely accepted principles of the Society for Information Technology (SITE, 2002). These are; technology should be infused into the entire teacher and student education programs. It should be introduced in context that students should experience technology-supported learning environments in their schools. Practical experience from across the world sustains such viewpoints but at the same time emphasizing the difficulties and challenges faced in the implementation of ICT in teaching and learning programmes in particular contexts.

2.4 The African Context

In Africa, there have been numerous international and national schemes over the last decade designed to introduce ICT into schools. Most of these have been introduced with the best of intentions, but many have failed to live up to the ambitious aspirations of those who have promoted them (LaRocque, N., and Latham, (2003). The ICT schemes have been top-down approach with insufficient attention being paid to the involvement and training of teachers and students. Nevertheless, there have been some interesting initiatives that have indeed sought to go beyond merely introducing computers into schools and giving teachers some training in basic ICT skills. Among these are; the Connectivity for Educator Development program in Uganda, Schools On-Line's programs in Senegal and Tanzania, World Links programs (in Ghana and Uganda) School Net in Kenya, the Commonwealth of Learning Southern Africa Teacher Training Program and NEPAD e-schools initiative.

Even with such programmes in place, significant implementation problems still exist. SRI (2001) evaluation of the World Links programmes reported the significant progress that *WorLdLinks* had made in spite of persistent barriers. For instance, in Latin America and Africa, teachers reported that the lack of computers, inadequate hardware/software, unreliable Internet access and the scarcity of time constituted the major barriers keeping them from using computers in their teaching (Wangeci, 2005). A smaller number of teachers in selected countries also indicated a need for more ICT technical support in integrating ICT into the curriculum and stronger national policies on the role of technology in student learning (Wangeci, 2005).

2.5 The Kenyan Context

Kenya is currently confronted with many educational challenges, which implies that the ambitious Millennium Development Goals and Kenya's Vision 2030 goals for education are unlikely to be met without well-trained, qualified and committed teachers. The use of

ICT is definitely not a cheap solution for teaching and learning. However, ICT can have a very significant role by facilitating the creation of new types of learning environment, supporting distance-based models of teacher training and by opening up a wealth of new educational resources.

In its 2005 ICT in Education Options Paper, Kenya recognized the many ways in which information and communications technologies (ICT) can support and improve the delivery of quality education for all Kenyans. These options are as per the educational priorities outlined in *Sessional Paper No. 1 of 2005* and the KESSP document, which include Quality Teaching and Learning through ICT; ICTs in Teacher Training Colleges; ICT for In-Service Teacher Training; Interactive Radio Instruction (IRI) for In-Service Teacher Training; Video for In-Service Teacher Training and Open and Distance Learning among others.

The Government of Kenya has consistently demonstrated its commitment towards the improvement of Education. The country has continuously reviewed the education system to make it more relevant to the needs of the country and in conformity with the international education trends (Ominde Report, 1964: Gachathi Report; 1976: Kamunge Report, 1988 and Koech Report, 2000). However, the implementation of ICT in education has encountered several challenges due to lack of funding (MoE, 2006). According to MoE(2006)' such challenges include Poor Access to computers by students and teachers. In most cases, the number of functioning computers in most school is low. This research investigated the effect of computer student ratio on the use of ICT in teaching and learning science curriculum in the selected schools. The condition of the computers may also not meet basic standards in some schools. For example, many of the computers that are donated to schools by different organizations have inadequate Random Access Memory (RAM), processors and software. Moreover, some machines had less storage space than the 64MB flash drive.

2.6 The School Environment and implementation of ICT in the Kenya Education System

The level of infrastructure provision in schools varies enormously across Kenya (George, 2006). This consideration should be taken when developing programs that use ICT in teaching and learning in the country. Factors influencing use of ICT in teaching and learning in urban schools in Kenya are often different from those across much of the rest of country (George G. (2006). Indeed, the digital divide has very much expressed itself across the country as a bandwidth divide. Good Broadband connectivity, for example, is now taken for granted in many of the richer countries of the world where educational software is increasingly being developed to take advantage of this. This access to the Internet is rare and expensive in Kenya. Although two-way satellite connectivity is now available across most of African countries, the costs of using this for educational purposes remain prohibitively high to be a sustainable choice for learning and teaching (Vanbuel, 2004).

Variability in infrastructure provision means in practice that use of ICT in teaching and learning science subjects will need to be thought through carefully in specific school contexts (MoE, 2006). Teachers and learners need to have access to similar training through different media depending on the infrastructure available to them. This is because schools located in urban areas have better ICT infrastructure and hence have a higher probability of effective utilization of ICT than those in rural areas. The present study investigated this assumption.

2.7 Access to ICT Infrastructure

Although there is no consistent relationship between the average amount of ICT use in schools and its apparent effectiveness in raising standards, the effective use of ICT in schools with good levels of ICT infrastructure can have a positive impact on students' achievement (Harrison et al., 2002). In addition, Hannele Niemi (2003) found that while the number of computers did not increase the use of ICT by teachers, proper infrastructure remains one of the main factors of the successful integration of ICT in education.

It is pertinent that issues to do with quantity and quality be examined together. For instance, it is pointless to provide schools with inadequate machines or without proper software. Apparently, there is a need for technical support and maintenance as soon as computers arrive into schools (Granger et al., 2002: Hakkarainen et al, 2001). Technical assistance is a key factor for implementing new innovations (Fullan, 1999). Unreliable ICT in schools has been found to be "the best innovation killer" (Hepp et al, 2004). There is often a significant, positive correlation between the technical assistance received by schools and their progress in implementing ICT into their teaching and learning (Byrom, 2001).

The Kenyan government is committed to the improvement of Education and has continuously reviewed the program to make it more relevant to the needs of the country and in tandem with the latest international trends in education as has been evidenced by various education commissions. However, due to lack of funding, however, a number of challenges have emerged in the implementation of use of ICT in teaching and learning in schools. Among the challenges, access to computers by students is poor, the number of functioning computers is low and sharing ratio of the available computers is considerably poor. In addition, the condition of the computers is below basic standards in most schools. Many of the computers were donated by different organizations and had inadequate Radom Access Memory (RAM), processors and software.

2.8 Teachers and Learners Training in ICT Technical Skills

The most referred obstacle to integration of ICT in teaching and learning in educational institutions is the lack of effective learner and teacher training in ICT technical skills (Albirini, 2006: Balanskat et al, 2006: Beggs, 2000: Özden, 2007: Schoepp, 2005: Sicilia, 2005: Toprakci, 2006). Pelgrum (2001) found that there existed little training opportunities for teachers in the use of ICT in a classroom environment in most schools in the world. Similarly, Beggs (2000) found that one of the top three barriers to teachers' use of ICT in teaching was the lack of training in ICT skills. The main problem with the implementation of ICT in teaching science subjects has also been attributed to insufficient amount of in-service ICT skills training for science teachers (Özden, 2007). Toprakci (2006) also concluded that limited teacher training in the use of ICT in Turkish schools was a major obstacle to its integration in teaching and learning.

According to Becta (2004), the issue of training is certainly complex because it is important to consider several factors to ensure the effectiveness of the training in the use of ICT in teaching and learning. He highlights three factors which must be considered in any training programme. These are: time for training, pedagogical training skills training, and an ICT use in initial teacher training. Correspondingly, recent research by Gomes (2005) relating to science education concluded that lack of training in digital literacy, lack of pedagogic and didactic training in how to use ICT in the classroom and lack of training concerning the use of technologies in science specific areas were obstacles to using ICT in classroom practice. Some of the Saudi Arabian studies reported similar reasons for failures in using educational technologies such as the weakness of teacher training in the use of computers (Alhamd, Alotaibi et al, 2004), as well as the shortage of teachers who are qualified to use the technology confidently (Sager, 2002). Inappropriate teacher training does not help teachers in using ICT in their classrooms and in preparing lessons (Cox et al. 2002 and Balanskat et al, 2006). This is because training programmes may not always focus on teachers' pedagogical practices in relation to ICT but on the development of ICT skills.

According to Becta (2004), beside the need for pedagogical training, it is still necessary to train teachers in specific ICT skills. When new technologies are integrated in the classroom, teachers have to be trained in the use of these particular ICT (Schoepp, 2005). According to Newhouse (2002), some initial training is needed for teachers to develop appropriate skills, knowledge and attitudes in regard to the effective use of computers to support learning. He argued that this also requires continuing provision of professional development to maintain appropriate skills and knowledge. Fundamentally, when there are new tools and approaches to teaching, teacher training is essential (Osborne and Hennessy, 2003) if teachers are to integrate the skills into their teaching. However, according to Balanskat et al. (2006), inadequate or inappropriate training leads to teachers being neither sufficiently prepared nor sufficiently confident to carry out full integration of ICT in the classroom.

There is general consensus that teachers need not only to be computer literate but they also need to develop skills in integrating computer use into their teaching and learning in classrooms (Newhouse, 2002). According to Newhouse (2002), teachers need training in ICT technical skills in order to support teaching in the classroom. Similarity, Sicilia (2005) found that although teachers wanted to learn how to use ICT in their classrooms, lack of opportunities for professional development in use of the technology obstructed them from integrating technology in certain subjects such as science. Other problematic issues related to professional development in ICT are that training courses are not developed to meet the specific learning needs of teachers (Balanskat et al., 2006). Lack of effective training in ICT skills is therefore a barrier to teachers' use of ICT in the classroom during teaching (Becta, 2004). Where training is ineffective, teachers may not be able access to ICT resources. Therefore, this study investigated the influence of training in ICT technical skills and the adoption of ICT in the teaching and learning of science-based subjects in the selected schools to establish if the training in the technology was an important factor in its integration in the science curriculum.

2.9 Pedagogical Skills and Use of ICT in Teaching Science Curriculum

In view of the profound educational changes brought about by the integration of computer technology into schools, teacher professional education and in-service training have taken a position of prime importance (van Weert 1995). This is more so because in African education systems devoid of resources and appropriate pedagogy are largely characterized by a chalk and talk mode of imparting knowledge (Stadler, 1991: Bouwer, 1998 Hayman, 1999: Bot, 1999). While many teachers lack the expertise and means to deal effectively with the unique cognitive needs of learners, most of the learners are faced with a critical lack of exposure to learning experiences, which Western curricula require for cognitive development and skills of self- learning (Bouwer, 1998).

According to Johnson (1995), only certain teaching models were applicable in the utilization of computers in education. These, he notes, are the constructivist approach to resource-based learning, authentic teaching and learning and project-oriented education, using authentic assessment. The resource-based method of teaching, for example, defines the position of a teacher as a facilitator in the learning process, rather than a source of knowledge (Karaliotas 1998). The student team model has also been used mostly in school computer projects, with the teacher librarian playing a dominant role (Arnall, 1995).

Writing from African perspective, O'Kennedy (1995) asserts that in using the computer as a technological tool, teachers will act more as facilitators, giving purpose to the learning experience. The implication is that much learning will be outside the teacher's sphere of influence. Lundall and Howell (2000) state that when computers are used in schools for the first time it is in a very rudimentary fashion, usually in the form of drill and practice, and a development period follows during which teachers and students become familiar with the technology.

Acquisition of ICT skills alone for teachers is not enough for the effective utilization of ICT pedagogically (Hakkarainen et al., 2001). According to Sabieh (2001), while it may be relatively simple to teach how to use technology, this is not the case when it comes to learning how to use technology as a pedagogical tool. Indeed teachers need ICT skills, but they also need knowledge and skills that enable them to use ICT in pedagogy. More often than not, ICT skills professional development focuses on teaching technical skills without showing teachers how to integrate these skills into their specific subjects' areas (Mathew et al., 2002: Sabieh, 2001). However, it is necessary to teach teachers how to incorporate what they learn in their teaching strategies and science activities (Sabieh, 2001). Accordingly, Somekh and Davis (1997) warned of much time spent on specific technical skills, which are not transferable to the classroom setting. Teacher training in form of isolated skills on hardware and software can have limited impact on teacher practice. According to Granger et al. (2002) and Brand (1997), isolated skills acquired during workshops and courses do not guarantee their use by teachers when they return to their classrooms. Consequently, sufficient attention needs to be focused on the transferability of the acquired skills into the classroom.

The impact of new knowledge and ICT skills acquired by teachers during their professional learning remains limited if teachers cannot implement them in their instruction. Graham and Thornley (2000) emphasize the importance of linking both pre- and in-service teacher education with classroom practices. They also suggest that in bridging theory and practice, teacher learning should shift from knowledge reproduction to knowledge use. Similarly, Browne and Ritchie (1991) state that typical ICT professional learning on isolated skills on hardware, software can be limited, and it does little to help transfer these skills to the classroom. This paper assessed the pedagogical skills attained by teachers during the implementation of ICT project in NEPAD and Cyber e-Schools.

2.10 The role of ICT infrastructure providers in Kenyan e-schools

Among the current most ambitious ICT infrastructure providers in Kenyan schools is the New Partnership for Africa Development (NEPAD) e-Africa commission (Mecer, 2005). The e-Africa commission initiative has advocated the e-Schools program for Africa's Development. This has been developed through various initiatives since its announcement at the Africa Economic Summit in Durban in June 2003. The important role of the teacher training in ICT skills development in schools has been emphasized. Nevertheless, as with so many other educational-ICT initiatives in Africa, its focus remains primarily on the importance of giving pupils and teachers ICT skills, rather than on using ICT to enhance their wider learning experiences.

At the All-Africa Ministers' conference on Open and Distance Learning held in Cape Town in February 2004, Kinyanjui (2004) stressed that the e-Schools initiative will ensure that a majority of the people on the continent have the skills required to function in the knowledge economy. He defined NEPAD's e-Schools' objectives as a bridge to the digital divide among young people. Its purpose is to ensure that every African youth leaving school has the necessary ICT skills that will assist them find jobs. He emphasized that acquisition of ICT skills among the youth would enable them get jobs or further their education optimally. NEPAD e-Africa initiative aimed at ensuring universal e-access in every institution a policy priority on African continent and to re-define universal service/access to meet the requirement of the new economy (Kinyanjui, 2004).

The NEPAD e-initiative aimed at connecting more than half a million primary and secondary schools in Africa to the Internet. However, without comprehensive frameworks developed at national level to train teachers in the appropriate use of such technology in teaching, it is likely that such activities will achieve little in the way of real educational change in the continent.

Some of the other players in the country that are involved in development of ICT infrastructure in schools in Kenya include the Kenya Institute of Education (KIE) which has been offering radio broadcast to schools since 1968. The main interest in ICTs in education is to ensure that GOK enacts policies that transform Kenya to a knowledge based country where e-government, e-education, e-health and e-agriculture are fully operational (KIPRA). KENET has delivered connectivity to over fifty higher education institutions. School Net Kenya has drawn up regional ICTs in education strategies for training thousands of teachers. Computers for Schools Kenya have installed computers in nearly 150 schools and provided sensitization, foundation skills, and integration training for principals and teachers. Computers for Schools Kenya (CSK) have also developed a computer refurbishment centre and have collaborated with KIE in e-content development. On the other hard African Virtual University (AVU) which is a satellite-based teaching network established through the World Bank in 1997 (African Virtual University, 2005) has initiated a continent-wide program on ICT integration in Teacher Education with funds from the African Development Bank (AFDB).

Network of Initiatives in Computer Education (NICE) which is an Education Trust in Kenya intends to reach all schools in Kenya. NICE hopes to particularly provide rural schools with basic computer literacy and with a vision of an ICT- competent 21st century generation benefiting from an increased opportunity in Information Technology. NICE includes a variety of NGOs, private sector partners and GOK institutions from the education sector. Members include Computers for Schools Kenya, Kenya Community Media Network, African Regional Centre for Computing, Kenya Private Sector Alliance – ICT Board, Hein land Institute, Rift Valley Institute of Science and Technology, Rural Schools Computer Project and KENET.

This study investigated the how the NEPAD and CSTS ICT schools programme influenced the use ICT in teaching science subjects in the selected school. This was to establish the extent to which their role-played in the effective implementation of use of ICT in teaching and learning. This was because their input was considered an important factor that could have contributed to uptake of ICT in teaching in the schools.

2.11 Computer Enhancement of Access to Information for Learning and Teaching

The advent of the computer has revolutionized learning related to accessing, evaluating and using information resources in a digital library environment in schools today (Neuman, 1997). A comprehensive understanding of computers and information technology should therefore focus on developing students' knowledge and skills (Todd (1997). He also recommends that there is need to manage process, utilize the enormous valuable and quality of information that ICT provides.

Hawkridge (2000) : Kidombo and Gakuu (2009), considering the relevance of computer literacy in schools, are of the opinion that computers have become catalysts for teaching and learning, helping students to be less dependent on teachers and enhancing collaborative learning. Thapisa and Birabwa (1998), however noted that, for developing nations to innovate and create stocks of information and knowledge by utilizing ICT, there is need for telecommunication networks that can support electronic data exchange. However, Muriithi (2005) argues that in Kenya like most developing countries ICT usage is still limited to computer literacy training. She contends that the present ICT curriculum merely deals with 'teaching about computers' and not how computers can be used to facilitate the teaching and learning in Kenyan schools. She suggests that, integration should consider pedagogy, the pattern of student use of ICT and the extent of use in teaching and learning. She proposes that a wide range of learning technologies should be selected and incorporated into the teaching and learning programmes.

Information literacy has been defined as incorporating computer literacy. This has received extensive coverage in the present study. Carbo (1997) emphasize that an information literate person must recognize the need for information, know how to access it, understand how to evaluate it, how to synthesize it and be able to communicate it. Clyde (1997) emphasizes that information literacy must begin with identification and definition of a problem, since the objective is to use information to solve problems. Information literacy is becoming a condition for playing a meaningful role in today's world and more so in teaching and learning science curriculum.

According to Clyde (1997) any quality of life beyond mere survival will depend on effective use of information skills. Campbell (1996) points out that, learning environment are now dominated by computers. The curricula have also changed in response to the new means of accessing information. She notes that classroom-based, textbook-oriented and teacher-directed learning cannot prepare students for the sort of future dominated by ICT. Beswick (1989) while discussing issues related to Internet connectivity noted that, technology brings about a heavy saturation of information systems. With information expanding at an exponential rate, Campbell (1996) is of the opinion that students need a new electrographic literacy to assimilate, digest, absorb and express the huge quantities of information that are now available through the emerging electronic technologies.

According to Springer (1997), students need to understand that a computer screen is more complex than a page in a book. A screen, unlike a page, has, in addition to the text, instructions and navigational tools. Students and teachers would need to become familiar with such conventions as icons, menu bars, outlines, bookmarks and coloured hypertext, used for navigation. He states that, considerable explicit instruction needs to be provided in using category menus, online indexes and simple and advanced keyword searching and "cut and paste" from the Internet to discourage useless print-outs (Springer,1997).

The essential skills of information retrieval, which have been examined by many scholars including Beswick (1989) : Eisenburg (1992) : Nahl and Harada (1996) and Herring (1996), are transferable skills, which can be used in both paper-based and electronic format. This include skills to conceptualize a search problem, analyse the problem, identify the source and locate the information, synthesize and process the information, evaluate and use the information for the relevant purpose. Information skills have been noted by the writers to be high-level thinking skills, which can only be acquired through systematic training and application. Herring (1996) reports on a project conducted by the United States National Council for Educational Technology (NCET), which examined the impact of using multimedia and the Internet in schools. It was established that planning on online searches was vital in learning. In terms of finding information, the project reported that the same retrieval skills are used with new electronic sources as with print; planning and refining searches was critical with electronic media; student's in some schools combined retrieving from electronic and print sources; retrieving information from the Internet was time-consuming and often difficult; and the type of information retrieved from the Internet was often unsuitable for curriculum use.

Behrens (1995) pointed out that in the United Kingdom and the United States of America, it is a requirement that students are equipped with information skills while they are still captive audience in the formal learning system. Furthermore, it is imperative that such skills are made part of the curriculum in all schools as Kenyan learning and teaching system is ushered into the information age, hence, the need to survey the role of acquisition of information skills by learners and science teachers in this study.

2.12 The Application of ICT in Teaching Science Curriculum

ICT has potential to change the teaching and learning science subjects. There is consistent evidence from the earliest days of educational ICT that when student's are given autonomy to derive and test their own ideas and understanding, their ways of learning change and there is improvement in their understanding and achievement (Papert, 1980: Niedderer et al, 1991: Mellar et al, 1994). The use of simulation has been found to enhance the learning of science subjects. The advantages and disadvantages of using ICT simulations in the school science laboratory are well-documented (Scaife and Wellington, 1993: Baggott, 1998).

Early studies demonstrated that when students use computers in learning science, they were able to engage in investigations that were not only impossible to replicate in a school laboratory, but also above the mathematical abilities of the learners (Papert, 1980: Kurland and Pea, 1983: Cox, 1984: CL1S, 1987). In these studies, substantial number of simulation and modelling programmes have been developed and evaluated. Bliss et al. (1992) distinguished simulations as the exploration of existing models and modelling as the expression of learners' ideas but constructing their own models. Mellar et al., (1994) demonstrated that student's were able to investigate much more complex models if they were provided in simulations than if they had to built their own. Cox (2000) has reviewed research carried out over the past two decades on educational use of ICT-based simulations and modelling, and concludes that, the main contribution made to student's understanding of science is through the acquisition of investigative skills and improved understanding of some scientific concepts and processes (Cox, 2000).

When using ICT in learning science subjects, students have been found to develop new strategies for problem solving by building models and creating new rules (Boohan, 1994). They were able to complete tasks of greater cognitive complexity than they would without the effect of the software (Wideman and Owston, 1988). Students are also able to test their own hypotheses by making informed predictions (Linn and Songer, 1993). They develop higher-order thinking skills (Cathcart, 1990) and are able to engage in complex causal reasoning (Mellar, 1994). Students have been shown to use more exploratory language to arrive at choices through discussion (Wild and Braid, 1996). The range of simulation and modelling activities allow for both expressive and exploratory learning activities (Mellar and Bliss, 1994). Exploratory learning activities involve the learner in exploring ideas about a topic presented by someone else (a teacher or expert). The ideas may often be quite different from those of the learners. Expressive learning activities involve learners in expressing their own ideas. Therefore, use of ICT in teaching and learning has the potential to enhance expressive learning activities that fits well with learning in science education.

In the past few decades, science curriculum has changed to match the new aims of science education and it will continue to change (Osborne and Hennessy, 2003). Osborne and Hennessy (2003) state that, the latest move towards teaching about science rather than teaching its content will require a significant change in its mode of teaching and learning. They emphasize that along with the changes in views on the nature of science and the role of science education, the increase in the use of ICT in teaching offers a challenge to learning of science subjects.

The potential benefits from the use of ICT for science learning have been reported in several other research studies (Gillespie, 2006: Murphy, 2006). One of these potential benefits is the encouragement of communication and collaboration in science research activities. According to Gillespie (2006), new technologies could be used in science subjects to enable students to collect science information and interact with multimedia resources such as images and videos. Murphy (2006) reviewed the impact of ICT on the teaching and learning of science in schools. She indicated that, Internet was used in teaching science as a reference source and as a means of communication. Use of ICT in teaching science tends to increase student motivation in learning (Osborne and Collins, 2000). In addition, it also facilitates clearer thinking and development of data interpretation skills (Newton and Rogers, 2003). Another benefit from using ICT in science education is that it expands the pedagogical resources available to science teachers (Al-Alwani, 2005).

Effective ways of utilizing the Internet when teaching science have been explored by Pickersgill, 2003). He found that the ease of Internet access allows teachers to help students to become experts in searching for information rather than receiving facts. His argues that this could increase the student's awareness of the importance of the world around them and of becoming scientifically literate members of the society. Kelleher (2000) reviewed recent developments in the use of ICT in science in classrooms. While he reported that, ICT cannot replace normal classroom teaching. His review also indicated that, ICT could provide positive forces in science classrooms for a deeper understanding of the principles and concepts of science and could be used to provide new, authentic, interesting, motivating, and successful science activities.

Computers could also serve as cognitive tools in teaching and learning science curriculum. This is because software programs are able to amplify, extend or enhance human cognition (Kozma, 1994). They are designed to aid users to be task oriented therefore allowing the performance to be open-ended and controlled by the learner (Konza, 1994). Fouche (1995) points out that ICT provokes the brainpower. The importance of computers in science education has prompted Todd (1997) to argue that a real learning revolution has started in which teachers use information technologies to provide learning experiences that are different from previous ones. Despite the advantages that computers offer in education, Bigum (1997) comments that, computers should not be seen as the only educational tool but also as one of a number of possible tools which could be used to teach content and skills.

According to World Bank (2006), in Africa, Latin America and poor countries, the majority of teachers not only lack adequate hardware and software, but also reliable Internet access. These are significant barriers to using computers assisted instructions for teaching science subjects in schools. With the increased momentum of ICT revolution sweeping across the world, there is the need for teaching and learning system in Kenya to change such that the computers are used in the classrooms. A diagnostic study as this one is needed to help the country move in this direction. With globalization and the world as a global village, a bridge is required across the digital divide in the teaching and learning process between the technologically rich developed countries and the technologically poor developing countries like Kenya.

In view of the profound educational changes brought about by the integration of computer technology into schools, teacher professional education and in-service training have taken a position of prime importance (van Weert 1995). This is more so because, in African, education systems are devoid of learning resources and appropriate pedagogy. Classroom teaching is often largely characterized by chalk and talk mode of imparting knowledge (Stadler, 1991: Bouwer, 1998: Hayman, 1999: Bot, 1999). While many teachers lack the expertise and means to deal effectively with the unique cognitive needs of learners, most of the learners lack exposure to learning experiences, which Western curricula require (Bouwer, 1998).

Literature reveals that only certain teaching models are applicable in the utilization of computers in teaching science subjects. Johnson, (1995) noted the constructivist approach to resource-based learning, authentic teaching and project-oriented learning as important models in integrating ICT in teaching science subjects. The resource-based method of teaching, for example, defines the position of a teacher as a facilitator in the learning process, rather than a source of knowledge (Karaliotas 1998). The student team model has been used mostly in school computer projects, with the teacher librarian playing a dominant role (Arnall, 1995).

Writing from African perspective, O'Kennedy (1995) points out that in using the computer as a technological tool, teachers act more as facilitators instead of dissemination of knowledge thus giving purpose to the learning experience. The implication is that, much learning will be outside the teacher's sphere of influence. Lundall and Howell (2000) state that, when computers are used in schools for the first time, it is in a very rudimentary fashion, usually a form of drill and practice and a development period follows during which teachers and students become familiar with the technology and may adopt it in learning and teaching later.

Acquisition of ICT skills alone for teachers is not enough for the effective pedagogical utilization of ICT in the classroom (Hakkarainen et al., 2001). According to Sabieh (2001), while it may be relatively simple to teach how to use technology, this is not the case when it comes to learning how to use technology as a pedagogical tool. Indeed, teachers need ICT skills but they also need knowledge and skills that enable them to use ICT in pedagogy. More often than not, ICT skills professional development focuses on teaching technical skills without showing teachers how to integrate these skills into their specific science subjects' areas (Mathew et al., 2002: Sabieh, 2001). However, it is necessary to teach teachers how to incorporate what they learn in their teaching strategies and science activities (Sabieh, 2001). Therefore, Somekh and Davis (1997) warned of much time spent on specific technical skills, which are not transferable to the classroom setting. Teacher training in form of isolated skills on hardware and software can have limited impact on teacher practice. According to Granger et al. (2002) and Brand (1997), isolated ICT skills do not guarantee their use by teachers when they return to their classrooms. Thus, serious attention must be given to the transferability of the acquired skills into the classroom situations.

The impact of new knowledge and ICT skills acquired by teachers during their professional learning remains limited if teachers cannot implement them in their instruction. Graham and Thornley (2000) noted the importance of linking both pre- and in-service teacher education with classroom practices. They also suggest that, in bridging theory and practice, teacher learning should shift from knowledge reproduction to knowledge use. Similarly, Browne and Ritchie (1991) state that typical ICT professional learning on isolated skills on hardware, software can be limited, and it does little to help transfer these skills to the classroom. This research assessed how prior pedagogical skills attained by teachers before the implementation of ICT project in NEPAD and Cyber e-Schools influenced their adoption of ICT in teaching and learning science subjects.

2.13 Transformation Strategy in Teaching and Learning Science Subjects

Learners commonly have trouble in applying appropriate knowledge to solve a novel problem. Consequently, a transformation strategy is needed to supplement and/or transform the existing knowledge base into real life situations (Desforges, 2000). There are indications that the dynamic representation of systems and the ability to interact with these models, which ICT enables, can assist students in developing an understanding of their scientific environment. This allows them to recognize the relevance of that experience in new situations (Friedler and McFarlane, 1997). This study made an effort to find out whether there is evidence that ICT is able to facilitate such knowledge transformation in science education.

It is widely accepted that student's try to construct their ideas about events and phenomena that they encounter in their science lessons upon experiences and interpretations that they have made previously. There is a considerable body of research evidence (Driver, 1983: Driver et al, 1984) suggesting that these "everyday" experiences help student's learning of scientific concepts. This is built upon the student's learning experiences during Science projects (CLIS, 1987).

The research in science education is also now focusing on the importance of language in the classroom. Based on an interest in how student's make meaning from the use of language in science lessons, it is now recognized that apart from the spoken and written word, many other communication factors are at work, for example eye contact, gesture, body language and movement (Kress et al., 2001). Research by this group has shown that talk is not always the dominant mode of communication in the science lessons. It has also been demonstrated that student's construct knowledge about core themes in science, such as cells and energy because of a range of activities (Jewitt and Scott, 2002). ICT activities such as computers based simulation models could therefore enhance knowledge transformations in a science curriculum .This study investigated this phenomenon by finding out how the use of digital science material enrich science activities during science lessons and hence help transformation of knowledge..

The cognitive tools embedded in ICT and the pedagogical knowledge content involved provides a powerful driver for the knowledge transformation that enables students to understand a new problem (Desforges, 2000: Baggott la Velle et al., 2001). Transformation does not take place in isolation but in a positive constructivist-learning environment (Vygotsky, 1978). ICT resources are part of learning environment and their effects are expressed in a social context with a rich, multi-media learning environment (Perkins, 1993). The notion of multi-modality has direct implications on the value of practical work in school science and whether ICT can augment or even replace it is a big debate (Millar and Osborne, 1998).

The debate is hinged on the point that science practical work is expensive, time consuming and involves small and often inaccurate data collection techniques in school laboratories. However, practical work can develop syntactic that is procedural knowledge but this element is also highly problematic since the students rarely experience the process as cyclical. Practical work and planning are separate tasks, writing up is often done at home and any evaluation or reconsideration most frequently occurs purely through a teachers with little or no discussion. ICT promises to provide a more effective method of developing both substantive and syntactic scientific understanding, answering the criticisms detailed above. Digitally presented data offer an alternative way to achieve learning objectives through computer simulations that generate the data (Baggott la Velle et al., 2001: McFarlane, 2002). There is evidence to suggest that students learn more about the underlying scientific processes using computer-generated models than they do in the laboratory setting (Linn, 1999).

2.14 The Theoretical frame work of the study

Learning environments in schools typically involve one or more teachers who interact with a number of learners, usually in well-defined physical settings. Both the teacher and the learner interact and form a variety of relationships, creating what Salomon (1994) calls a system of interrelated factors that jointly affect learning interactions with the relevant individuals .This is what Wubbels et al (1991) also term as the "relationship dimension" in a classroom environment.

The learning environment has a physical as well as a relationship dimension. Physically it may be in a room full of particular furniture and equipment. Curriculum materials such as books and videotapes may also be present. The curriculum also has a place in the relationship dimension of the environment in that, students and teacher(s) are focused on certain processes and content in the curriculum. They also relate with that curriculum and the methodologies that are associated with conveying the curriculum. Learners and teachers may have very different relationships with different components of the curriculum as exemplified in Fig. 2.1(a).

The place of computers in learning is most likely to occur in the classroom in the school and at home. Most experts in the field of educational computing (Lynch, 1990: Olson, 1988: Rieber, 1994) characterize computers as interactive and place them within the relationship structure of the ICT enhanced classroom-learning environment. The classroom learning environments that incorporate computers or ICT is demonstrated in Figure 2.1 (b).

Learning and Teaching Classroom Environment

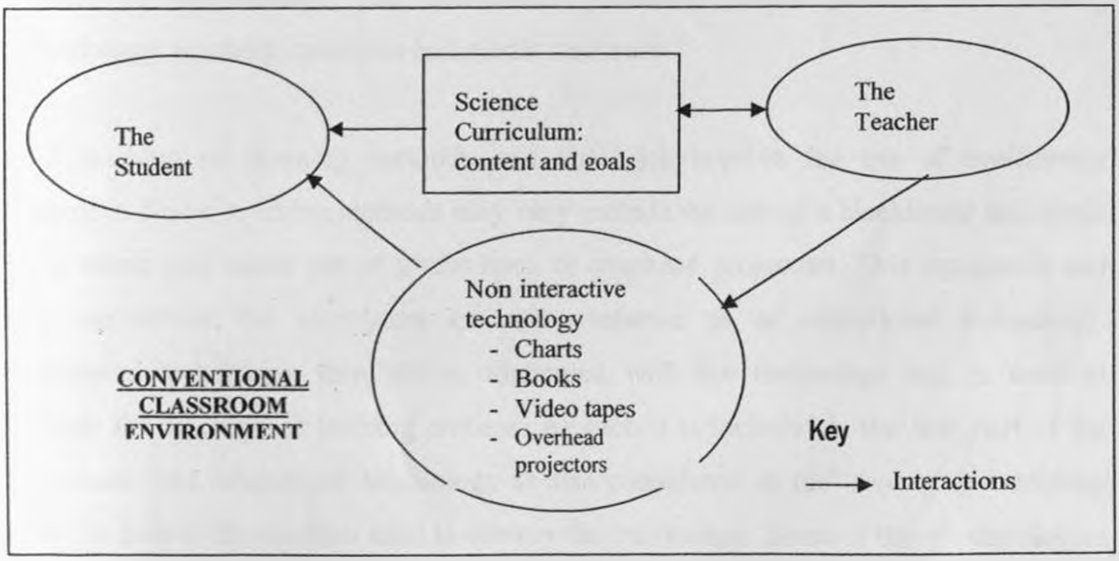


Figure 2.1a: **Conventional Classroom learning and teaching environment**

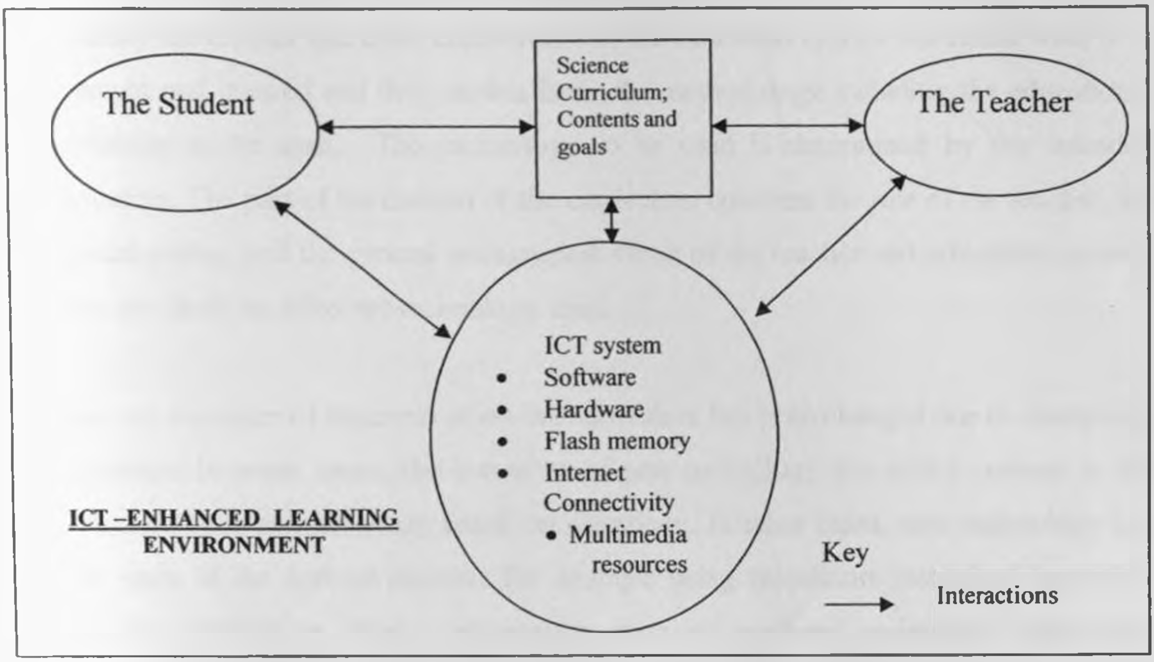


Figure 2.1(b): **ICT enhanced learning and teaching classroom environment**

The curriculum is concerned with what is learned and taught and how this learning and teaching occurs. What is learned or taught includes objectives, content, and learning outcomes, that is, the knowledge acquired, skills and attitudes that students are intended to demonstrate. The curriculum concerns include teaching or learning methodology, teaching strategies and media resources.

Most teaching or learning methods and strategies involve the use of multimedia equipment. Some teaching methods may only include the use of a blackboard and chalk while others may make use of a television or overhead projectors. This equipment and their use within the curriculum are often referred to as educational technology. Educational technology therefore is concerned with the technology that is used to facilitate the teaching or learning process. As such it is included in the *how* part of the curriculum. The educational technology is also considered as the" *tool of the teaching trade"* as part of the medium used to convey the curriculum. Some of these technologies involve the use of computers.

There are two-way relationships between the curriculum and educational technology. Typically the teacher and other components of the education system determine what is to be taught and learned and then on this basis the methodology including the educational technology to be used. The technology to be used is determined by the intended curriculum. The part of the context of the curriculum concerns the role of the teacher, the physical setting and the general pedagogical views of the teacher and education system. These are likely to affect the technology used.

There are a number of instances when the curriculum has been changed due to changes in technology. In some cases, the invention of new technology has added content to the curriculum such as technology based on electricity. In other cases, new technology has made parts of the content obsolete for example using calculators instead of logarithm tables for calculation. Some technologies such as overhead projectors, videos and computers have led to the development of new methods of learning and teaching which were not feasible before their introduction. Therefore, in my view technology can affect the curriculum both in terms of content and methodology of delivery applied.

Already it would appear that the content and objectives of the curriculum are changing to take account of the role of computers in society. For example, with the use of large database systems such as the Web on the Internet, it is more important to know how to retrieve and manipulate information than to remember the information itself. However, in other applications of computers in any curriculum design teachers and students will need to decide the situations in which the curriculum best needs the use of computers and where use of ICT may be inappropriate.

As indicated in Figure 2.1, computer systems (hardware and software) become involved in the interaction patterns within the classroom environment. This is not possible with the other educational technologies that are non-interactive. For example, an overhead projector affect the classroom environment in that it takes up space, it requires a screen, a teacher needs to create transparencies to use on it and students may not like reading them, there is no two-way interaction as may be the case with a computer system. A computer system can interact with each student and the teacher differently and can interact with components of the curriculum in different ways.

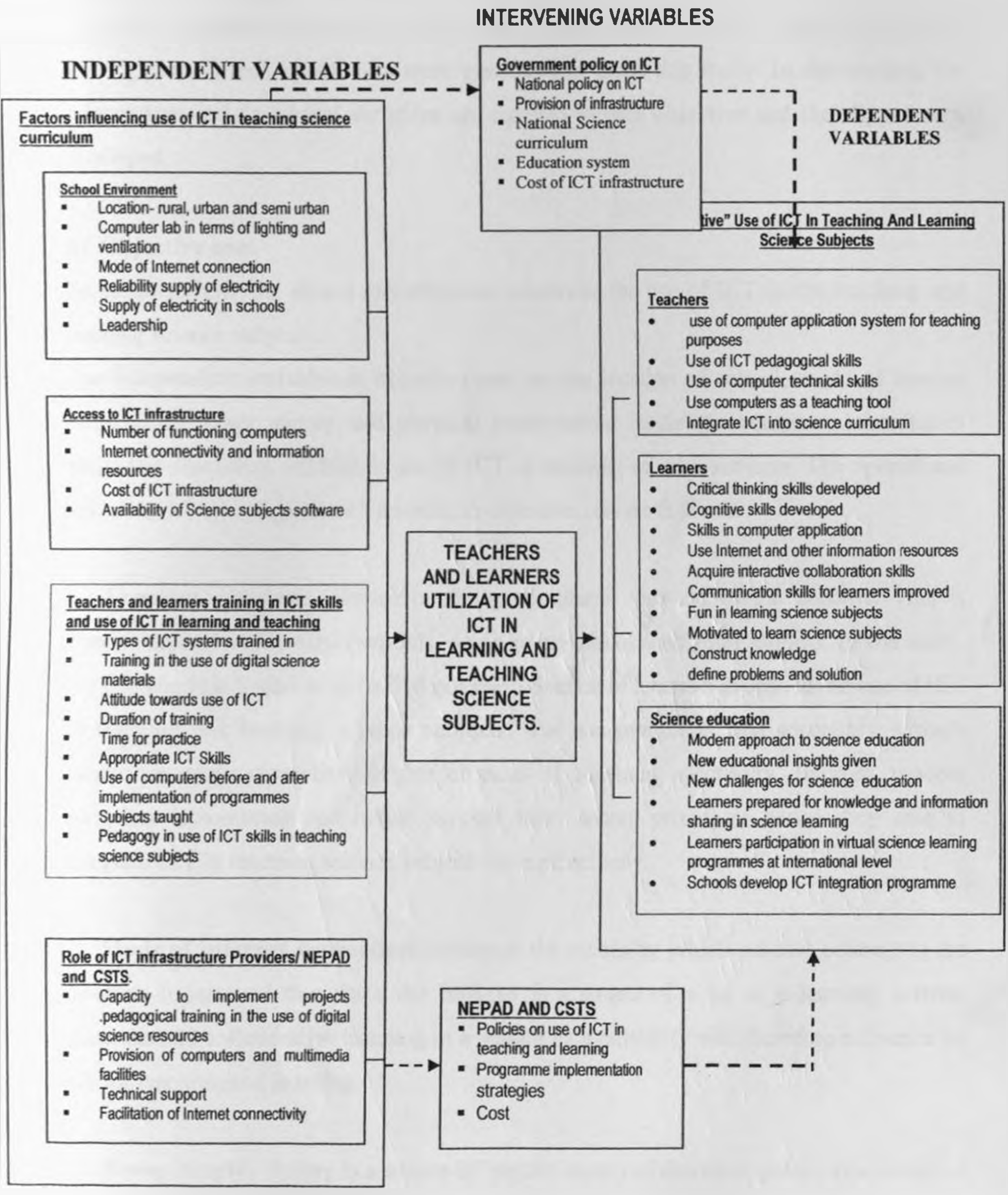
2.15 Conceptual Framework

The ultimate aim of the various ICT projects in secondary schools is to prepare learners for integration into the knowledge and information age economy, where prompt access to information or knowledge enables individuals to play worthwhile role in life. This study is based on the assumption that the use of computers affects the motivation of students in the learning and enjoyment of science subjects and that appropriate use of software packages can enrich, support and mediate effective learning of science concepts.

The four principal issues that form the basis of this study include: access to ICT infrastructure including multimedia facilities; training of teachers and learners in useful ICT skills for learning and teaching; the school environment and ICT infrastructure providers as important factors in the implementation and use of ICT in teaching and learning science curriculum. The present investigation is underpinned by the theory of constructivism, a philosophy that perceives learning as a process of adjusting mental models to accommodate new experiences. This also involves constructing knowledge, developing thinking skills, building learners' ability to reflect, and generating strategies for defining a problem and working out solutions rather than working on answers that a teacher wants (Sultan and Woods, 2009 : Muyinda and Lubega, 2009). This means that learning how to learn, knowing how to know and contextualization of learning are some of the features of constructivism (Duffy and Cunningham, 1996: Funderstanding, 2001). ICT has potential to enhance this essential pedagogical skill in teaching and learning science subjects in Kenya.

This study investigated the extent to which this pedagogical paradigm has been utilized during use of ICT in teaching and learning in Cyber and NEPAD e-schools in order to enhance effective learning and teaching of science curriculum. This was based on the premise that computers should not be used to disseminate knowledge but rather be used as a support tool that help the learners to experience and build scientific knowledge. Consequently, any tools that can encourage the use of constructivist in classroom practices and promotion of development of thinking skills in learners should be considered essential for all teachers, students and related e-media resources, computer use and schools ICT infrastructure. Hence, the need for this study to establish the factors influencing the "effective" use of ICT in teaching and learning in science curriculum in selected schools in Kenya.

Fig. 2.2 A conceptual frame work of the variables influencing the use of ICT in learning and teaching science curriculum



2.16 Study hypotheses

From the literature reviewed in this study underpinning the four objectives of this investigation, fifteen hypotheses were generated to guide this study. In this section, the independent and dependent variables are isolated in each objective and then hypotheses developed.

a) Objective one:

To establish how the school environment influences the use of ICT in the teaching and learning science subjects.

The independent variables in objective one are the location of school, mode of Internet connection, power supply and physical environment inside the computer laboratories while the dependent variable is use of ICT in teaching science subjects. The operational definition of the independent variables in objective one are follows:

i. **Location of school**: Refers to the geographical location of the schools. This is operationalised as the urban schools, semi-urban schools and rural schools. In the study, the hypothesis is tested so as to find out the influence of location of schools on use of ICT in teaching and learning science subjects. The assumption is that secondary schools located in urban areas have higher chances of accessing electricity, Internet, modern computer laboratories and better support from school principals hence they able to integrate ICT in teaching science subject more effectively.

ii. **Mode of Internet connection**: Refers to the means by which schools connect to the Internet. It assumed that since the Internet is a source of a lot of e-learning science materials and collaborative learning in a school its availability will therefore influence its use for teaching and learning.

iii. **Power supply**: Refers to a source of regular supply of electrical power to a circuit or device that must be operated within certain power supply limits. The assumption of this was that even if all other ICT infrastructures were in place without electricity, learning using ICT will not take place and that science teachers will therefore most likely revert to the conventional mode of teaching (chalk and talk).

iv. **Physical factors inside computer laboratory**: Refers to the physical condition of computer laboratory in terms of Lighting, ventilation, furniture and noise level. The assumption of this study was that computer laboratory which had good lighting, well ventilated, good furniture and reduced noise would influence use of ICT teaching and learning.

v. **Use of ICT in teaching science subjects**: Refers to the frequency teachers use various ICT tools in teaching science subjects as reported by the respondents. It is assumed that teachers use ICT as a teaching tool if other ICT related factors are met.

The dependent variable in objective one is the use of ICT in teaching science subjects. This stands for whether a teacher has ever used ICT in teaching science subjects and the frequency of use. The following four hypotheses were generated which are consistent with objective one of this study.

H1a: **The location of schools does not influence the use of ICT in teaching science subjects**

H1b: **The access to Internet services in schools does not influence the use of ICT in teaching science subjects**

H1c: **The power supply does not influence use of ICT in teaching and learning science subjects**

H1d: **The physical environment inside the computer laboratories does not have influence on the use of ICT in teaching and learning**

b) Objective two:

To determine how access to computers and other ICT infrastructure (including multimedia facilities) affect the use of ICT in the teaching and learning strategies used in the science curriculum.

In objective two, the independent variables considered include the number of working computers, network connections, availability of file server, teacher's ability to use the multimedia and students access to ICT skills. The dependent variable is the use of ICT in teaching science subjects. The indicators of the dependent variable and the independent variable are operationally defined as follows:

i. **Number of working computers**: Defined as the number of computers which could be shared by learners during ICT based science subjects. It was assumed that availability of working computers would influence use of ICT in teaching science subjects.

ii. **Computer networks**: Refers to a group of computers that are interconnected by electronic circuits or wireless transmissions of various designs and technologies for the purpose of exchanging data or communicating information between them or their users. The assumption made in this study is that availability of computer network will influence use of ICT in teaching science subjects since some science digital materials are normally installed in one machine and shared to other machines through local area network

iii. **Availability of file server**: Refers to a computer running a server operating system capable of providing services to other computers in a network. The assumption for file server was that since file servers are used to installing digital science materials which is shared to other computers, lack of it may impend effective use of ICT in teaching science subjects.

iv. **Computers sharing ratio**: Refers to the number of students sharing one computer at the same time. It was assumed that for purposes of efficiency and effectiveness in using ICT in teaching science curriculum in schools, computers for both teachers and students should be available most preferably at 1:1 ratio so as to increase learner's concentration and capacity to absorb all learning materials thus positively influencing use of ICT in teaching and learning.

The dependent variable in objective two is the use of ICT in teaching science subjects. This stands for whether a teacher has ever used ICT in teaching science subjects and the frequency of use. The following hypothesis were generated which are consistent to objective two of this study.

H2a: **The number of working computers does not influence use of ICT in teaching and learning science subjects**

H2b: **The network connection does not influence the use of ICT in teaching and learning science subjects**

H2c: **The availability of file server does not influence use of ICT in teaching and learning science subjects**

H2d: **The student's computer sharing ratio does not influence the use of ICT for learning purposes.**

c) Object three:

To verify how the training of teachers and learners in ICT skills influences the use of ICT in learning and teaching science subjects.

In objective three, the independent variable is form of ICT trainings teachers and learners received, whereas the dependent variable is use of ICT in teaching and learning science subjects. The indicators of the dependent variable is use of ICT in teaching and learning and the independent variable includes access to ICT training skills, duration of training in basic ICT skills, teacher's technical competence and training in pedagogical skills are defined as follows:

i. **Access to ICT training skills**: Refers to participation in ICT skills development programmes. The assumption for this was that training in acquisition of ICT skills could influence its use in teaching science subjects, as teachers are likely to have confidence in using ICT facilities in their schools.

ii. **Duration of basic training in ICT skills**: This refers to the number of days the ICT training course took. The assumption was that the length of training period would increase conceptualization of the basic ICT skills and thus influence use of ICT in teaching and learning.

iii. **Teacher's technical competence**: This refers to the abilities of teachers to fix minor computer hardware and software problems. The assumption was that lack of technical competence would impede the effective utilization of ICT, since a lot of time would be lost as school seek for technical assistance which may not be forthcoming thus influencing use of ICT in teaching and learning.

iv. **Training in pedagogical skills**: Refer to knowledge that teachers develop with respect to their teaching methods. The assumption is that use of ICT in teaching science subjects were influenced by abilities in various pedagogical skills.

v. The dependent variable is the use of ICT in teaching science subjects. This stands for whether a teacher has ever used ICT in teaching science subjects and the frequency of use. The following hypotheses were generated which are consistent with objective three of this study.

H3a: **The level of ICT trainings teachers and learners received does not influence the use of ICT in teaching science subjects in NEPAD and Cyber e-schools.**

H3b: **The duration of ICT skills training does not influence the use of ICT in teaching and learning science subjects.**

H3c: **The teachers' technical competence does not influence their use of ICT in teaching and learning science subjects.**

H3d: **The training in pedagogical skills does not influence use of ICT in teaching and learning science subjects.**

d) Objective four:

Identify the role of ICT infrastructure providers in the use of ICT in teaching and learning science subjects in NEPAD and Cyber e-Schools.

In objective four, the independent variables are the roles of infrastructures provider's (NEPAD and Cyber projects, and technical Support received by secondary schools, whereas the dependent variable is use of ICT in teaching science subjects. The indicators of dependent variables and the independent variables are defined follow:

i. **Role of infrastructure providers**: Refers to the prerequisites ICT facilitation provided by NEPAD and Cyber e-Schools in terms of hardware and software in support for integration of ICT in teaching and learning in schools. The assumption is that teachers from schools well ICT resourced will use ICT more effectively than resource-deprived schools.

ii. **Technical Support**: Refers to the type and magnitude to support received by schools. The assumption was that the kind and magnitude of technical support received by school would influence the use of ICT in teaching and learning.

iii. The dependent variable is the use of ICT in teaching science subjects. This stands for whether a teacher has ever used ICT in teaching science subjects and the frequency of use. The following hypothesis were generated which are consistent to objective four of this study.

iv. H4a: **The role of ICT infrastructure providers does not influence the use of ICT in teaching and learning science subjects**

H4b: **The technical support received by the e-Schools does not influence the use of ICT in teaching and learning science subjects..**

2.17 Summary

Chapter Two comprehensively reviewed literature relevant to the utilization of Information and Communication technology in teaching and learning in both globally and locally in Kenya. This literature was beneficial in the formulation of the research problem. It also examined the factors which influence the effective use of ICT in teaching and learning science curriculum and the hypotheses that guided this investigation. The review of literature also focused on communities that have had access to the new technology and presented evidence from previous investigations from which lessons could be drawn. In addition, the review incorporated findings of the ICT potential in teaching and learning science curriculum in Kenya using evidence drawn from selected schools.

In Kenya, there have been several infrastructure constraints in use of ICT in teaching and learning. These include; lack of Internet connectivity, insufficient number of computers, lack of ICT skills and technical support among learners and teachers. Due to the awareness created by NEPAD and CSTS ICT initiatives, ICT integration into learning and teaching is already gaining momentum. However, there is a need to create more awareness at the national level of how ICT could enhance teaching and learning particularly in science curriculum.

Many secondary schools in Kenya are already utilizing ICTs in education to address access, equity, and quality of education through the implementation of various projects.

With greater coordination, these projects can provide valuable lessons to meet GOK's goal of Education for All. GOK has already identified ICT as a critical tool for creating greater enthusiasm for learning amongst students and offering access to a wider range of its population.

The relevance of ICT in teaching and learning, as well as the challenges that are likely to impede its utilization in developing countries like Kenya has been discussed. The Literature Review elucidated that very little study have been carried out on the ICT potential in tackling the problems facing teaching and learning science subjects in Kenya. This study focused on factors that influence (independent variables) "effective use" (dependent variables) of ICT in teaching science curriculum in NEPAD and Cyber e-schools to provide information on a typical ICT integration in teaching science curriculum in Kenya and NEPAD projects. This could provide the basis for the envisaged roll out programme for NEPAD and CSTS ICT e-initiatives.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology adopted in the investigation including the research design, data collection methods, data collection instruments, the research population, the sampling techniques, pre-testing of research instruments and analytical methods. The research methodology will also explain the relationship between the Research Problem, Literature Review, and data collection techniques, instruments and data analysis.

3.2 Research Design

The purpose and objectives of a research will determine the type of research design employed in a study (Katundu, 1998). Given the nature of the research problem and purpose of the present study, the most appropriate research methodology was through a descriptive survey or the *ex-post facto* design. According to Busha and Harter (1980), this research method is capable of collecting background information and also the researcher has little opportunity to motivate or influence respondents' responses. Sproull (1995) also recommends the survey technique for research where attitudes, ideas, comments and public opinion on a problem or issue such as the one under study. The descriptive survey approach was chosen for the present study, because it sought to gain insight into a phenomenon as a means of providing basic information in this area of study (Bless and Higson-Smith, 1995).

The strengths of the survey method were also evident in this study because of its ability to study, describe, explore and analyse relationships among scattered variables such as the use of ICT in teaching and learning initiatives in the schools included in this study. As a result, the Researcher applied the information gathered from a small sample to a large population. The investigation further employed the *ex-post facto* design which is a systematic empirical inquiry without direct control of variables which could not be either manipulated or because their manifestations had already taken place (Kerlinger, 1973)

3.3 Target population

Leedy (1993) observed that a careful consideration is needed during basic planning of a research and selection of the study population. This research therefore took care, precession and thorough consideration during the selection of the research population. The study was conducted in secondary schools that participated in the Cyber Schools Technology Solutions (CSTS) project and NEPAD e-Schools initiative projects. The selection of the NEPAD e-schools for the study was purposive (Fraenkel and Wallen, 2000). All the six secondary schools were implementing ICT programmes and were funded by NEPAD e-Africa initiative commission. They had the necessary ICT infrastructure or had initiated use of ICT in the curriculum used for teaching science.

Through their own initiative or through Ministry of Education support the Cyber e-schools have acquired digital science learning materials at a cost from CSTS. The schools also have put up basic ICT infrastructure through their own financing or through government financial support. The implementation of ICT in education was a necessary condition for this investigation.

3.4 Units of Analysis and Observation

According to Singleton et al. (1988), a unit of analysis is what or who is to be described or analyzed. Shutt (1996) describes a unit of analysis as the level of social life on which research questions focus. The units of analysis in this study were Cyber and NEPAD e-schools. The units of observation were the teachers, learners and school environment in the selected schools. Science teachers in these schools were treated as key informants.

3.5 Sampling Procedure

Sampling procedures were conducted to ensure that conclusions from the study were generalized to the entire population. Teachers in the NEPAD programme were not sampled because e-schools were few and hence all the science teachers in the schools participated in the ICT programme. However, 30 per cent the teachers in the sampled Cyber e-Schools that were in CSTS programme were selected through simple random sampling for this study (Fraenkel and Wallen, 2000).

A stratified random sampling procedure was used to determine the number of learners to be sampled for purposes of the present investigation. To ensure that the sample was representative of a population about which there was a fair amount of information available, the population was divided into sub-groups (Mulder, 1993). The student population of 3,577 was divided into sub-groups according to their class levels which were categorized as Form One, Two, Three and Four.

Teachers carried out the sampling of learners in a systematic manner. A rigorous procedure was applied to avoid bias and maintain a representation of the diverse groups of learners in each school. A simple random sampling procedure (Fraenkel and Wallen, 2000) was adopted to select learners to answer the questionnaire as recommended by Steyn (1994) who states that, with a simple random sample, each element in the population stands an equal chance of being selected in the next draw.

The sample size in each school was twenty per cent of the student population that were using ICT for learning science subjects. This number was determined by the researcher with help of teachers and rounded off to the nearest whole number. The sample size was determined by the number of learners presented by each school. A strict simple random sampling process was discussed with teachers. The following procedures were followed in the selection of learner respondents in this study:

i. Teachers provided each learner in their class with a number from 01 – 0N (N represents the number of the last learner) on the sampling day.
ii. A row in a table of random numbers was selected at random.
iii. Teachers chose the sampled numbers provided to students from the table, beginning with the first number selected at random. For example, if a teacher selects a random number of 91 in the table of random numbers, he would select the first random learner 01.
iv. The teacher went through the list (row by row) and determined the numbers that corresponded with any of the numbers of respondents in the class.
v. The process in step three was repeated until the number of selected respondents was completed.
vi. The selected students were requested to complete the questionnaires. The simple random sampling procedure adopted in this study corresponded with the five steps of simple random sampling proposed by de Vaus (1991). In total, Cyber School Technology Solutions (CSTS) was supporting 30 secondary schools out of which 20% of them were (six schools) were selected using simple random sampling method. The sampling method allowed the researcher to use cases that have the required information and facilities (Fraenkel and Wallen, 2000) with respect to the problem and objectives of the study. The schools selected were public and teach the main science subjects in the secondary schools science curriculum in Kenya, that is, Mathematics, Physics, Biology and chemistry.
vii. A list of schools that were participating and using ICT for learning science curriculum in NEPAD and Cyber School Technology Solutions (CSTS) programmes is provided in Appendix A. Further, Table 3.1 outlines the schools and numbers of teachers and students that were selected for purposes of this investigation.

Table 3.1 Selected NEPAD demonstration e-schools and Cyber e-schools

	Categories of Schools	Region/province	Number of science teachers		Number of students	
			No (N)	No sampled (n)	No (N)	No sampled (n)
	Cyber E-Schools Programme					
1	Mitamboni Mixed Secondary	Eastern	4	4	432	87
2	Muruguru Secondary School	Central	4	4	368	74
3	Nairobi School	Nairobi	4	2	710	142
4	Nakuru Boys High School	Rift Valley	4	4	684	137
5	Ol'Kalou Mixed Secondary School	Central	4	4	324	136
6	Shariani Secondary School	Coast	4	4	285	57
NEPAD e-Schools PROGRAMME						
1	Wajir Girls secondary	North Eastern	4	4	422	84
2	Menengai Mixed secondary	Rift Valley	4	4	320	64
3	Isiolo Girls Secondary School	Eastern	4	4	380	76
4	Mumbi Girls secondary	Central	4	3	602	120
5	Chavakali High school	Western	4	3	750	150
6	Maranda High school	Nyanza	4	2	831	116
Total Number of Students			**48**	**41**	**6108**	**1243**

3.6 Data collection method

The study used both qualitative and quantitative research methods. According to King et al (1994), the styles of both methods differ in that the quantitative uses numbers and statistical methods and is based on the numerical measurements of specific aspects of a phenomenon. It abstracts from particular instances to test causal hypotheses or seek general description. It involves measurements and analysis that are easily replicable by other researchers. Qualitative research does not rely on numerical measurement. It focuses on small number of cases, uses in depth interviews and observation techniques. According to Singleton et al. (1988), it entails general discussions and individual questions that are developed spontaneously in the course of the interview and is concerned with a comprehensive account of an event.

In this study, an interview schedule was constructed and used to conduct in depth interviews with key informants in the respective schools chosen for the study. The observation technique was also used to collect accurate information on the endeavours of the various schools and teachers to use ICT in learning and teaching science subjects. The information gathered was used to add value to the findings and act as a complement to the information collected using the questionnaires to highlight on the factors that influence use of ICT in teaching sciences in the selected schools.

Primary data was obtained from students in the respective schools using face-to-face structured interviews based on standardized questionnaires that had open and close - ended questions. This involved a set of predetermined questions and highly standardized techniques of recording. Other methods used for the study included sources such as documentation in schools, online data, interviews, focus group discussions and observations. Secondary data was collected from books, journals, unpublished research work, the Internet, and magazines.

3.7 Data collection instruments

A self-administered questionnaire as a primary data collection tool was the main method used to collect data in the present study. This questionnaire was semi-structured and consisted of both closed and open-ended questions. De Vaus (1991) provides a number of advantages of closed questions. He states that, closed questionnaires are easier to code and recommends exhaustive alternative responses as a remedy to the problems. Open-ended questions have been included in the questionnaires in the present study to determine the general feelings of teachers and students on issues and the reasons for their opinions.

There were two sets of questionnaires for the teachers and students respectively. The teacher questionnaire was divided into six sections. Section A elicited demographic information, Section B elicited information of the physical environment factors in schools which affect teaching and learning science subjects. Section C focused on the access to ICT infrastructure in schools, while Section D assessed different ICT skills teachers had accessed. Section E assessed the role of ICT in fracture providers/ NEPAD and CSTS. Finally, Section F assessed the benefits and challenges of the ICT programme.

The Researcher made efforts to ensure that the questions found in the questionnaires were fairly simple and straight forward. Considerable attention was given to developing simple, clear and unambiguous questions using simple terminology. For instance, the generic reference to a "computer system" was used instead of the phrase Information and Communication Technology (ICT). Hence, the teachers and students were able to fill in the questionnaires without much assistance.

The questionnaires were also designed to fulfil specific objectives of the investigation (Leedy, 1997). The questionnaires for this study were designed to fulfil the objectives listed in Chapter One of this research report. The variables, from which the sub-questions for the questionnaires have been deduced, are also provided in Chapter Two. Two sets of questionnaires were designed for data collection. One set of the questionnaires was used for the science teachers involved in ICT programme while the other set was given to students/learners. Two sets of questionnaires were used because the study was intended to elicit views from teachers and learners of the selected schools.

Questionnaires have been identified as one of the best impersonal observation technique used for eliciting data (Leedy, 1993). In this investigation, it was assumed that the respondents were more likely to respond honestly because of anonymity. Questionnaires were also used because it was not possible for the researcher to interview all teachers and twenty per cent of the learners in each of the schools covered in the research population. A further reason for using self-administered questionnaires was that, the schools were scattered across eight provinces of Kenya, financial, logistical and time constraints would not have allowed interviews to be used as the main data collection technique for this research.

The questionnaires were supplemented by telephone interviews where necessary and face to face interviews with school principals and science teachers. This procedure gave clarity on issues therefore reducing the ambiguity that goes with questionnaires. In addition, the researcher's made observations of the actual status of use of ICT infrastructure in teaching science subjects in the selected schools. The researcher agree with Katundu (1998), that the use of more than one data gathering instrument and the triangulation method is vital in an under-researched problem such as in the present study.

The researcher did the administration of data collection instruments during both pilot and the main study. A letter of introduction from University of Nairobi was issued and a research permit obtained from the Office of the President. A copy of the permit was presented to Education Department in all the Districts where the selected schools were located. Thereafter, the researcher paid a courtesy call at Divisional Education offices. Letters of introduction were sent to all the head teachers of all the schools participating in the main study before its commencement. Each principal was informed that their school had been selected for the purpose of the present study and their contribution would be highly appreciated.

With the help of research assistants, the Researcher visited the schools to administer the questionnaires to the teachers and learners. During the data-gathering exercise, respondents were assured that strict confidentially would be maintained in dealing with their responses. This assisted the Researcher to establish rapport with his respondents, so as to gain their acceptance and trust. To ensure full co-operation from respondents, the researcher explained to them the significance of the study and the importance of their participation.

Due to the vast distance between each of the schools, the researcher administered and collected the questionnaires the same day from each school visited. This ensured that the respondents did not discuss or modify responses. However, special arrangements were often made for a second visit to collect questionnaires in cases where it was not possible to collect them on the same day.

3.8 Validity and Reliability of research instruments

The questionnaires were pre-tested in two secondary schools each representing the two categories of schools – NEPAD and Cyber e-schools used in this study. The purpose was to test the instruments for validity and reliability (Nevell, 1993) and to determine how realistic the questions were to the ability of learners and teachers. Nevell (1993) stressed the importance of scrutinizing data gathering instruments to identify ambiguity, misleading questions or instructions and suggesting improvements. Minor changes were made after the pre-tests in collaboration with the supervisors of this study.

3.8.1 Validity

It is always important to validate the degree to which evidence supports the inferences made using data obtained in a research (Fraenkel and Wallen, 2000). In this study this was done in order to ensure appropriate inferences were made that were relevant and related to the purpose of the research. The content validity included assessment of clarity of printing, appropriateness of the language or questions, direction and relevance of research objectives. The researcher outlined the operational definitions and objectives that were being measured in this study. Thereafter, lists of operational definitions, objectives of the study and the questionnaires were given to the three supervisors to evaluate appropriateness of each question or item in the two sets of instruments. The responses from the three supervisors were analysed. The instruments were restructured as per the recommendations of the supervisors. The instruments were resubmitted to the supervisors for a final validation and thereafter restructured and accepted by the researcher. The modified questions or items of the instruments were printed and administered to the learners and teachers.

3.8.2 Reliability

Reliability of research instrument refers to the level of internal consistency on the stability of the measuring device (Thorndike and Hagen, 1961). An instrument is reliable when it can measure a variable accurately and consistently and obtain the same results under the same conditions over time. Roescoe (1969), recommends the split-half procedure for assessing reliability of an instrument. Nachmias and Nachmias (1976): Lokesh (1984) and Gall et al. (1996), concurs with this. This involved breaking the instrument items into two equivalent halves, namely, the odd-numbered and even–numbered items. All the odd-numbered items were placed in one subset, while all the even-numbered items were placed in another subset. Each of the two sub-sets was treated separately and scored accordingly. The scores of each of the two sub-sets were then computed and the two scores corrected using Spearman-Brown prophecy (Fraenkel and Wallen, 2000) and then this was taken to be an estimate of reliability coefficient of the whole inventory.

To following formulae was used to calculate correlation coefficient of the entire test (Re).

$$Re = \frac{2r}{1+r}$$

Where:

Re = Correlation Coefficient of the entire test (reliability)

2r= Correlation Coefficient of the even numbered statement with the scores of the Odd numbers statements.

r=` indicates the degree to which the two halves/subsets were internally consistent.

In this study, the correlation coefficient of 0.56 was obtained by comparing one half of the test questions to the other half. Therefore, the reliability of the research instruments was:

Reliability of score of the instruments (Re) $= \frac{2 \text{ X } 0.56}{1 + 0.56} = \frac{1.12}{1.56} = 0.72$

Reliability coefficient ranges from values of 0.000 and +1.00 indicating perfect reliability. In this investigation, the reliability coefficient was found to be 0.72 which meant that the instrument could be relied on to make valid conclusions.

3.9 Data Analysis Techniques

In the process of bringing order, structure and interpretation to the mass of collected data, both qualitative and quantitative data was analyzed. The data analysis was initiated by examining the gathered raw data for accuracy, usefulness and completeness. The objective behind editing was to identify those items that were incorrectly responded to such as spelling mistakes and blank spaces left unfilled by the respondents. The data was divided into two categories, namely:

i. Data collected from the teachers
ii. Data collected from the students.

This data was then tabulated and classified in qualified terms (Lokesh, 1984). This involved the transfer of classified data gathering tools to the tabular form in which they were systematically examined. Descriptive statistics was adopted for presenting and analyzing the data patterns in the responses from the sample were summarized by the use of frequency tables and percentages (De Vaus, 1991). However, inferential statistics were used, where necessary, to determine if the patterns described in the sample could be applied to the population from which the sample was drawn.

3.9.1 Coding of the closed questions

There was a need to allocate a code to the answers of each question or variable. De Vaus (1991) indicated that the essence of coding is to give a distinctive number to each answer in a question. The number was fed into the computer. A pre-coding procedure was adopted for computer data analysis. This was because most of the questions (over 85%) were closed questions, with predetermined answers to each question. It was therefore necessary to allocate codes to the answers.

3.9.2 Coding of the open-ended questions

According to De Vaus (1991), open-ended questions often produce multiple responses that require the creation of several variables to capture the responses. It was therefore best to construct a number of variables into which responses could be sorted out then coded. A multiple response approach was used for coding the open-ended questions in this study. A post-coding procedure was used. Categories were created from the responses received to a particular question. A code was allocated to a particular category, for respondents' answers.

3.9.3 Qualitative data Analysis

The researcher identified how the general statements on themes of the data were related. The data collected underwent processes of organization, clustering, interpreting and conclusion. The next stage was to organize this data by selecting, simplifying and deduction from written field notes. This was to ensure that the data was manageable and comprehensive, and could be used to give preliminary conclusions. The analysis also included drawing conclusions and verifications where data irregularities, explanations and causal flaws were noted. Final conclusions were tested for plausibility and conformability.

3.9.4 Quantitative Data Analysis

The data gathered from the structured questionnaires was edited for completeness and consistency before processing. This was then coded to enable the responses to be grouped into categories. Descriptive statistics were used to summarize the data, to enable the researcher to meaningfully describe a distribution of scores or measurements using a few statistics. Types of statistics used depended on the type of variable in the study and the scale of measurement for example ratio, interval, ordinal or nominal.

The correlation analysis was used to analyze the degree of relationship between two variables. The study used the Pearson Product- Moment Correlation to show the degree of the influence, ranging from negative one (-1) to positive one (+1). Pearson product moment correlation of coefficient was computed for various measures. This correlation was used for interval data, spearman's rank-order for nominal and ordinal data and multiple regression analysis were used to evaluate the relationships between the dependent variables and the independent variables.

The Pearson correlation coefficient r measured linear association between two variables and the Spearman correlation coefficient, measured association between rank orders. Values of both range between -1 (a perfect negative relationship) and +1 (a perfect positive relationship) were observed. A value of zero indicated no linear relationship while the significant variable at $p<0.000$ and $p<0.05$ level of significance were isolated and used in this study. The choice of these statistical methods was based on measurement scales and aim of the study was to test the relationship between various ICT related variables of the study. However, gender of respondents, teaching experience and professional qualification of teachers were assessed in relation to use of ICT in teaching and learning science subjects.

Statistical Package for Social Science (SPSS) was used to analyze the data. The frequency distribution was examined by looking at the issues that were represented by the respondents and the most typical responses.

Table 3.2: Operational definitions of factors influencing the use of ICT in teaching the Science curriculum

	Objectives	Research Questions	Variables/ Indicators// Dimensions	Hypothesis	Types of analysis
1	To establish how the schools' environment influences the use of ICT in teaching and learning science subjects.	What were the specific environmental characteristics of the schools, which had influenced the use of ICT in teaching science curriculum in the	Location of e-schools- rural, urban and semi urban	H1a: The location of schools does not influence the use of ICT in teaching science subjects	Descriptive statistics, regression, Chi-Square
			Mode of Internet connection	H1b: There access to Internet services in schools does not influence the use of ICT in teaching science subjects	Descriptive statistics, Regression Chi-Square

		selected schools?	Power supply to schools	H1c: The power supply does not influence the use of ICT in teaching and learning science subjects	Descriptive statistics, regression
			Physical environment in the Computer laboratory	H1d: The physical environment inside the computer laboratories does not influence the use of ICT in teaching and learning science subjects.	Descriptive statistics, Regression Chi-Square
2	To determine how access to computers and other ICT infrastructure including multimedia facilities affect the use of ICT in teaching and learning science curriculum.	How had the access to computers and other ICT infrastructure including multimedia facilities influenced use of ICT in teaching science curriculum?	Number of functioning computers	H2a: There number of working computers does not influence the use of ICT for teaching and learning science subjects	Descriptive statistics, regression
			Network connection	H2b: The network connection does not influence the use of ICT in teaching and learning science subjects	Descriptive statistics, Regression Chi-Square
			Availability of file server	H2c: The availability of file server does not influence the use of ICT in teaching and learning science subjects	Descriptive statistics, Regression Chi-Square
			Computer sharing ratio.	H2d: The students computer sharing ratio does not influence thee use of computer in learning and teaching science subjects..	Descriptive statistics, Regression Chi-Square
3	Verify how the training of the teachers and learners in ICT skills influenced the use of ICT in learning and teaching science subjects.	How had the training of teachers and learners in ICT skills influenced use of ICT in teaching and learning science curriculum in the selected schools?	Types of ICT skills in which teachers received training. Training in the use of digital science materials	H3a: The level of ICT trainings teachers and learners received does not influence use of ICT in teaching science subjects in NEPAD and Cyber e-schools.	Descriptive statistics, Regression Chi-Square
			Duration of training	H3b: The duration of ICT skills training does not influence the use of ICT in teaching and learning science subjects.	Descriptive statistics, regression
			Basic ICT Technical skills	H3c: The teachers technical competence does not influence their use of ICT for teaching and learning.	Descriptive statistics, Regression Chi-Square
			Pedagogical skills in use of ICT in teaching science subjects	H3d: The training in pedagogical skills does not influence the use of ICT in teaching and learning science subjects.	Descriptive statistics, Regression Chi-Square
4	Identify the role of ICT infrastructure providers in use of ICT in teaching and learning science subjects in NEPAD and Cyber e-Schools.	How did the current roles of ICT infrastructure providers influence the use of ICT in learning and teaching science subjects in NEPAD and Cyber e-schools?	Capacity to implement projects	H4a: The role of ICT infrastructure providers does not influence use of ICT in teaching and learning science subjects	Descriptive statistics, regression Chi-Square
			Technical support	H4b: The technical support received by the e-Schools does not influence the use of ICT in teaching and learning.	Descriptive statistics, Regression Chi-Square

3.10 Summary

This chapter has described the research methodology, data collection methods and tools used during this investigation. The research questionnaires and their specific administration have also been discussed. The study population provided details of the range and location of individuals covered in the study. In addition, the sampling procedures involved method adopted in limiting the range to specific individuals. The data analysis included the use of a coding method, descriptive statistic and correlation analysis of the relevant variables.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

The aim of this chapter is to provide a summary of the data collected from the two sets of questionnaires. General trends are explained using percentages, tables, figures and descriptions of data as a way to present the findings of the investigation. The Researcher with the help of trained research assistant collected the survey data through questionnaires, interviews and through personal observation of the activities in the NEPAD and sampled Cyber e-Schools. The data gathered was then analyzed using the Statistical Package for Social Science (SPSS). The findings are presented as per the objectives, research questions and hypotheses of the study.

The tasks in the questionnaires were divided into three sections. Section one consists of demographical information dealing with gender, age, educational qualifications and number of years in teaching profession. Section two includes tasks eliciting the views of the teachers and learners towards the use of ICT in teaching and learning science subjects, teaching delivery, and management. Section three consists of the views of the teachers and learners in regard to the characteristics of the use of ICT in teaching and learning science subjects.

The study results are presented in two sections, namely: descriptive analysis and test of hypotheses. The first stage was to report all the information related to each of the respondents' personal profiles. This was followed by data analysis in relation to the four main research objectives which included the specific environmental characteristics of the schools which influenced use of ICT in teaching and learning science subjects. It was considered important to evaluate the access to ICT infrastructure including multimedia facilities, training of teachers and learners in ICT skills and how the current roles of ICT infrastructure providers influenced use of ICT in learning and teaching science subjects in

NEPAD and Cyber e-schools. A summary of this data was then used to test the hypotheses that were outlined in Chapter Two of this dissertation. The study hypotheses were tested using a regression analysis and the chi-square test. This Chapter concludes by highlighting the main findings obtained from the quantitative data.

Section A – Descriptive Data Analysis

In this section, descriptive statistics were used to describe in quantitative terms the main features of the collected data. Tables giving the overall sample size, demographic characteristics, the proportion of subjects with each objective of the study are outlined.

4.1.2 Representation of Sampled Schools

Twelve secondary schools spread out in the eight provinces of Kenya which were either participating in NEPAD e-schools or CSTS schools digital science program were studied. Six schools included all the NEPAD demonstration e-schools in Kenya and the other six were selected through simple random sampling procedure from the Cyber e- schools. All the twelve schools that formed the research population that participated in this study translate to 100% participation.

One thousand and thirty six learners (1036) out of 1243 were selected through simple random sampling procedure. This translated to 83.5% level of participation. This sample consisted 49.2% of learners from NEPAD e-schools and 50.8% from Cyber e-schools. A response rate of 98.8% was achieved from learners. The teachers return rate was 41 out of the expected 48 which translate to 85.4%. The entire return rates were statistically representative, therefore, enhancing generalization of the research results. However, the statistical results were triangulated with extensive literature to draw lessons learnt from other similar works where research in implementation of ICT in teaching and learning has been carried out. Table 4.1 shows students representations per category of schools (NEPAD and Cyber e-Schools).

Table 4.1: NEPAD and Cyber e-Schools

	Categories of Schools	Region	Number of science teachers who participated		Number of students targeted	
			Expected	**Actual**	**Expected**	**Actual**
	Cyber E-Schools Programme					
1	Mitamboni Mixed Secondary	Eastern	4	4	87	78
2	Muruguru Sec. Sch.	Central	4	4	74	68
3	Nairobi School	Nairobi	4	2	142	107
4	Nakuru Boys High School	Nakuru	4	4	137	115
5	Ol'Kalou Mixed Secondary School	Central	4	4	136	115
6	Shariani Sec. Sch.	Coast	4	4	57	43
				21	**633**	**526**
NEPAD e-Schools Programme						
1	Wajir Girls secondary	North Eastern	4	4	84	64
2	Menengai Mixed secondary	Rift Valley	4	4	64	56
3	Isiolo Girls Sec. Sch.	Eastern	4	4	76	60
4	Mumbi Girls secondary	Central	4	3	120	104
5	Chavakali High school	Western	4	3	150	124
6	Maranda High school	Nyanza	4	2	116	102
				20	**610**	**510**
Total Number of participants			**48**	**41**	**1243**	**1036**
			Freq.	**%**	**Freq.**	**%**
Percentage return rates (%)		**Cyber e-Schools**	**21**	**51.2%**	**526**	**49.2%**
		NEPAD e-Schools	**20**	**48.8%**	**510**	**50.8%**

Source: field data

4.2 Characteristics of respondents

This section describes the demographic characteristics of science teachers and learners. These characteristics include teachers and learner's gender, education level of teachers and learners grade/class, teachers teaching experience and the subjects being taught by the teachers. The results are presented in Tables 4.2, 4.3, 4.4, 4.5, 4.6 and 4.7.

4.2.1 Gender of teachers

Although teaching profession has almost equal distribution of gender (ratio of males to females), the findings of this study shows that teaching of science subjects is dominated by males teachers. About 73.8% of the teachers who participated in this study were males while 26.2% were females. Table 4.2 shows the gender representation of teachers.

Table 4.2: Gender representation of teachers

	Male		Female	
	Freq. (n)	%	Freq. (n)	%
Cyber School	17	40.5	6	14.3
NEPAD	14	33.3	5	11.9
Total	31	73.8%	11	26.2

Source: field data

4.2.2 Education level of teachers

There is agreement in the literature that teachers need to master ICT skills, which will enable them to use technology effectively in their teaching. It has been acknowledged that education level of teachers is a key factor in successful implementation of the integration of ICT in teaching and learning. Traditionally, education researchers and planners have believed that professionally trained teachers are more efficient and effective in their teaching activities than untrained ones. Majority of the sampled teacher (55.3%) had Bachelor of Education (B.Ed.) 7.9% had a Masters degree in Education while 36.8% had Diplomas in Education. Table 4.3 shows the highest education attainment of the teachers.

Table 4.3: Education level of teachers

	Diploma in Education		Bachelor of Education (B.Ed.)		Masters in Education (M.Ed.)	
	Freq.	%	Freq.	%	Freq.	%
Cyber School	8	21.1	10	26.3	1	2.6
NEPAD	6	15.8	11	28.9	2	5.3
Total	14	36.8	21	55.3	3	7.9

Source: field data

4.2.3 Teaching experience

The findings of this study show that majority of the teachers 61.9% had teaching experience of between six to fifteen years. Those that were highly experienced had over sixteen years in teaching profession. The teachers that had the least experience in teaching science subjects (less than five years) were 26.2%. This study shows that, majority of the sampled teachers were very experienced in their work while a third of them were newly appointed and possibly had little experience in teaching science subjects. Table 4.4 shows the teachers teaching experience.

Table 4.4: Teaching experience

	Under 5yrs		6 to 15 years		Over 16 years	
	Freq.	%	Freq.	%	Freq.	%
Cyber School	7	16.7	14	33.3	2	4.8
NEPAD	4	9.5	12	28.6	3	7.1
Total	11	26.2	26	61.9	5	11.9

4.2.4 Subjects taught by teachers

This study targeted science teachers in schools that were implementing ICT programs in teaching science curriculum. Majority of the teachers 42.9% were biology teachers, mathematics teachers were 31.0% while physics teachers were 19.0%. Chemistry had the least representation at 7.1%. However, the sampled teachers were teaching combined science subjects thus resulting in almost equal representation. Table 4.5 below shows the science subjects taught by the sampled teachers.

Table 4.5: Subjects taught

	Biology		Chemistry		Math's		Physics	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Cyber School	11	26.2	2	4.8	6	14.3	4	9.5
NEPAD	7	16.7	1	2.4	7	16.7	4	9.5
Total	18	42.9	3	7.1	13	31.0	8	19.0

4.2.5 Gender of Students

One thousand and thirty six (1036) learners participated in the study as respondents. 56 per cent of the learner respondents were male while 43.9% were female. The NEPAD e-schools project had a component that targeted increase of ICT literacy among girls in secondary schools to bridge the gender digital divide. Hence, the possible reason why there were more girls' schools than boy's schools in the project .Table 4.6 shows gender representation of students.

Table 4.6: Gender representation of students

	Male		Female	
	Freq.	%	Freq.	%
Cyber School	363	35.0	163	15.7
NEPAD	218	21.0	292	28.2
Total	**581**	**56.1**	**455**	**43.9**

4.2.6 Class level of learners

Most of the learners that participated in the both NEPAD and Cyber e-schools programme were in Form Two (41.8%); Form One (32.2%), Form Three (24.0%), with the lowest numbers of learners being in Form Four (2.0%). Table 4.7 shows the Classes/Form (level) of the sampled learners.

Table 4.7: Class level of the learners

	Form One		Form Two		Form Three		Form Four	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Cyber School	145	14.0	239	23.1	128	12.4	14	1.4
NEPAD	188	18.2	194	18.7	120	11.6	7	0.7
Total	333	32.2	433	41.8	248	24.0	21	2.0

Source: field data

4.3 The School Environment

The first objective of this study was to establish how the schools' environment influenced the effective use of ICT in teaching and learning science subjects. This was done in order to answer the first research question "what are the characteristics of the schools, which have influenced effective use of ICT in teaching science curriculum in the selected schools?" The geographical locations of schools were assessed, physical aspects of classroom environment - computers' location in schools and room condition, availability of electricity, which in turn dictates availability of Internet facilities. This section details the findings.

4.3.1 Areas where the schools were located

There is a likelihood of a relationship between access to ICT prerequisites for example electricity, telecommunication, and Internet connectivity. This can influence either success or failure of a school to utilize of ICT in teaching and learning science subjects. Over half of the sampled secondary schools 54.8% were located in semi-urban areas, 36.8% were in urban areas while 8.4% were in rural areas. Table 4.8 shows areas where different categories of schools were located.

Table 4.8: Area / environment where the schools were located

	Urban		**Semi-urban**		**Rural**	
	Freq.	%	Freq.	%	Freq.	%
Cyber School	265	25.6	208	20.1	51	4.9
NEPAD	115	11.1	359	34.7	36	3.5
Total	380	36.8	567	54.8	87	8.4

4.3.2 Physical environment of computer laboratories

The location of computers in schools can determine the ease of their access by teachers and students. In particular, teachers and students' utilization of ICT can be restricted when access is confined to computer laboratories. The access to computers in the majority of schools was in fact restricted to computer laboratories. Teachers expressed the need for more access to ICT especially outside computer laboratories. In one of the teachers words," I believe that we need computers, data projectors, and scanners in classrooms", instead of computer laboratories. Other teachers proposed that computer laboratories should be made available for all subjects all the time. A number of teachers during group discussions indicated the need to have computers in classrooms to be able to teach some of the new digitized curricula with efficiency and ease. Respondents were asked to rate their computer laboratory in terms of internal lighting, ventilation, furniture and space.

The lighting in the laboratories was rated well by 26.2% of the respondents. 59.5% indicated that it was good while 11.9% indicated that it was fair. However, 2.4% respondents indicated that their computer laboratories had very poor internal lighting. In terms of ventilation, majority 45.2% of the respondents indicated that their computer laboratories had very good ventilation, 28.6% cited that the ventilation was good while 19.0% rated it fair. However, 4.8% rated it poor while 2.4% indicated that it was very poor.

Lack of space and overcrowding in laboratories was evident. In total, 33.3% of the respondents indicated that the laboratories had fair space, 21.4% indicated the space is poor while 9.5% indicated that space is very poor. Only a few of the secondary schools had spacious computer laboratories as was indicated by 26.2% of the respondents while 9.5% indicated that the space in their computer laboratories was good. Though, 26.2% of the respondents rated the furniture in their computer laboratories as very good and 45.2% rated them good, it is evident that in this research uncomfortable furniture was another major problem experienced by both students and teachers in some secondary schools. This is affirmed by 16.7% who rated them fair, 9.5% rated them poor while 2.4% rated them very poor. There is need for institutions to invest in purchasing of good chairs and computer desk that are comfortable.

Noise, unnecessary movements and commotion was relatively fair in majority of the selected schools 40.5% while 7.1% indicated that it was a major problem in their schools.

However, 21.4% indicated that noise level in their computer laboratories was reasonable while 31.0% indicated that it was good. The respondents also indicated that the slow response of computers to commands, and slow Internet accessibility were a major setbacks in the use of computers for teaching and learning science curriculum. This may be due to the fact that, the bandwidth of the Internet service providers (ISP) is small; the computers are not well maintained. Some users also did not know how to use the computers effectively. Table 4.9 shows the physical aspects of classroom environment.

Table 4.9: Physical aspects of classroom environment

		Very good	Good	Fair	Poor	Very poor
Lighting	Cyber e-Schools	11.9%	38.1%	4.8%		0.0%
	NEPAD e-Schools	14.3%	21.4%	7.1%		2.4%
	All schools	26.2%	59.5%	11.9%		2.4%
Ventilation	Cyber e-Schools	19.0%	19.0%	14.3%	2.4%	0.0%
	NEPAD e-Schools	26.2%	9.5%	4.8%	2.4%	2.4%
	All schools	45.2%	28.6%	19.0%	4.8%	2.4%
Furniture	Cyber e-Schools	7.1%	31.0%	7.1%	9.5%	0.0%
	NEPAD e-Schools	19.0%	14.3%	9.5%	0.0%	2.4%
	All schools	26.2%	45.2%	16.7%	9.5%	2.4%
Noise level	Cyber e-Schools	11.9%	23.8%	19.0%	0.0%	
	NEPAD e-Schools	9.5%	7.1%	21.4%	7.1%	
	All schools	21.4%	31.0%	40.5%	7.1%	
Space	Cyber e-Schools	7.1%	9.5%	19.0%	16.7%	2.4%
	NEPAD e-Schools	19.0%	0.0%	14.3%	4.8%	7.1%
	All schools	26.2%	9.5%	33.3%	21.4%	9.5%

Source: field data

4.3.3 Power Supply to e-Schools

In Kenya, power supply is not reliable due to frequent disruptions. This had a negative effect on the computer usage in some of the selected e-schools. In this study, 10.7% of the sampled secondary schools had no electricity but relied on diesel driven generators for power supply. In the 89.3% of the secondary schools which had power supply, it was restricted to areas such as the principals' offices, office reception and staff rooms but not in any of the classrooms. It can therefore be argued that, the environment in which the schools are located affects availability of permanent power supply, which in turn will affect utilization of ICT. Table 4.10 shows the supply of electricity in the sampled schools.

Table 4.10: Availability of permanent power supply

Students in :	Yes		No	
	Freq.	%	Freq.	%
Cyber School	465	45.9	45	4.4
NEPAD	440	43.4	64	6.3
All schools	905	89.3	109	10.7

Source: field data

4.3.4 Reliable supply of electricity

The study found that 39.8% of the schools had unreliable electricity, in the sense that they frequently experienced power failures for two or more days in a row. The majority of teachers claimed that they were unable to rely on the current state of the electricity supply to plan their science lessons or science activities. Most schools could not afford generators let alone fuel necessary to drive the generators. Only one schools had a back-up functioning generator. However, 48.6% of the schools had reliable source of power supply while 11.7% had very reliable electricity supply. Table 4.11 shows reliability of supply of electricity in schools.

Table 4.11: Reliability of electricity supply

		Cyber School		NEPAD		All schools	
		Freq.	%	Freq.	%	Freq.	%
a)	**Very reliable**	44	4.4	47	4.7	91	9.1
b)	**Reliable**	243	24.4	241	24.2	484	48.6
c)	**Unreliable**	15	1.5	10	1.0	25	2.5
d)	**Very unreliable**	204	20.5	192	19.3	396	39.8

Source: field data

4.3.5 Mode of Internet connection

For most schools that had access to Internet it was by fixed line infrastructure (wires). None of the institutions had the broadband wireless connection. It total, 29.4% used dial-up connection using telephone lines, 23.5% had integrated services digital network ISDN while 47.1% used ADSL lease line to connect to the Internet. It can therefore be argued that, the classroom teaching and learning environments are still very much traditional without much Internet influence in teaching and learning science subjects. Table 4.12 shows mode of Internet connection.

Table 4.12: Mode of Internet connection

	dial up modem(14.4 to 56k)		Integrated Services Digital Network (ISDN)		lease line(ADSL)	
	Freq.	%	Freq.	%	Freq.	%
NEPAD e-Schools	1	5.9	4	23.5	4	23.5
Cyber e-Schools	4	23.5	0	0.0	4	23.5
Total	5	29.4	4	23.5	8	47.1

Source: field data

4.3.6 Leadership offered by School Principals

The literature emphasizes the crucial role of school leadership in ICT integration across education, and shows how school leadership can hinder or facilitate schools adoption of ICT (Earley et al, 2004: Fink, 2005: Fullan, 1999: Fullan, 2003: Reynolds et al, 2000:Richardson, 2005: Tyack et al, 1994). Only 9.5% of teachers from both NEPAD and cyber e-Schools indicated that their administrators were supportive of ICT integration and the support was linked to principals' belief in the usefulness of ICT. Forty percent (40.0%) indicated that the level of support raged between 50%-70%. Forty seven point six percent (47.6%) indicated that the support was luke-warm while 2.4% felt that there was no support.

During discussions with teachers, a general consensus was that the integration of ICT in teaching and learning was still slow among the Principals themselves. Majority of the principals did not use the Internet. The reasons given for this poor support was highlighted as due to administrative ignorance of the role of ICT in learning and teaching. Lack of resources, which is a combination of lack of funds and technical equipments, also played a significant part in the principals' negative attitude towards ICT usage in teaching and learning science curriculum. Table 4.13 shows level of support offered by schools principals.

Table 4.13: Leadership offered by school principals

Types of schools	very suppotive-75% to 100%	Suppotive-50% to 75%	Luke warm support-25% to 50%	not supportive-0% to 25%
Cyber Schools	38.1%	11.9%	4.8%	0.0%
NEPAD e-schools	9.5%	28.6%	4.8%	2.4%
All schools	47.6%	40.5%	9.5%	2.4%

Source: field data

4.4 Access to ICT Infrastructure

The second objective of this study was to establish how access to computers and other ICT infrastructure including multimedia facilities affect use of ICT in teaching and learning science curriculum. This was done in order to answer the research question: "*How have access to computers and other ICT infrastructure including multimedia facilities influenced use of ICT in teaching science curriculum*?" The availability of computers and their peripherals that support integration of ICT, the number of computer connected to the Internet, access to computer and sharing ratio was assessed and discussed.

The problems encountered and extent to which they are experienced in use of ICT facilities during learning as a result of access was assessed. The impact of access of computers for learning science subjects on both teachers and learners has also been assessed and discussed. Lastly, the benefits of ICT project in schools and challenges encountered by NEPAD and CSTS in implementing integration of ICT in teaching and learning science curriculum in the e-schools was also investigated. This section details the findings.

4.4.1 Number of personal computers available in the e-Schools

The respondents were asked to state the number of computers available in their institutions. The following were the findings. Half (50.0%) of them had less than 20 computers, 30.0% had between 21-30 computers, while 10.0% had between 31-40 and above. On average, there were 10 computers per school that were selected for this study. However, not all the computers were in working condition. The number of these computers could not meet the needs of the high number of students and science teachers in the selected institutions. In this situation, even where computers were available, the computer to student ratio was high. Table 4.14 shows the number of personal computers available in the e-schools.

Table 4.14: Number of personal computers

No.	Number of personal computer	Percentage (%)
1	20 and below	50.0
2	21-40	30.0
3	41-50	10.0
4	51 and above	10.0

Source: field data

4.4.2 Availability of computer peripherals

Only a limited number of schools had computers that had CD ROM drives. The majority 37.1% had less than five computers with working CD-ROM drives, 29.4% had 6 to 10, and 18.9% had 11-15 while 14.7% had more than five computers fitted with CD-ROM drives. On average, there were four computers per school that had CD-ROM drives. However, many of these CD-ROM drives were not in use since not many secondary schools had science digital learning materials in form of CDs. This indicated a low access to computers with CD-ROM drives. Table 4.15 shows the number of personal computers fixed with CD-ROM drives.

Table 4.15: Number of personal computers with CD-ROM drives

	Number of personal computer with CD-ROM	Percentage (%)
1	Less than 5	37.1
2	6 – 10	29.4
3	11 – 15	18.9
4	More than 16	14.7

Source: field data

4.4.3 Number of computers connected to Internet

Access to the Internet greatly varied among schools. Majority (46.2%) of the sampled secondary schools had only one computer connected to Internet. About 7.7% had two computers connected to Internet, 15.4% had three while 30.8% indicated that they had an average of 20 computers (all computers in the laboratories) connected to Internet. Nevertheless, teachers complained about the quality of Internet speed. Teachers complained that, although the available training courses are well prepared and good the technology is inadequate to achieve what they were trained for. Table 4.16 shows the number of personal computers connected to Internet.

Table 4.16:` Number of computers connected to the Internet

	One		Two		Three		All	
	Freq	%	Freq.	%	Freq.	%	Freq	%
NEPAD e-schools	2	15.4	0	0.0	0	0.0	3	23.1
Cyber e-schools	4	30.8	1	7.7	2	15.4	1	7.7
Total	6	46.2	1	7.7	2	15.4	4	30.8

Source: field data

4.4.4 Computer access and sharing ratio

In NEPAD schools, 10.1% of the schools had a sharing ratio of 1:1, 18.1% had a sharing ratio 1:2 while 8.1% had a sharing ratio of 1:3 and 13.9% of more than three. In Cyber e-Schools, 5.7% of the schools had a computer sharing ratio of 1:1, 18.1% shared at 1:2, 9.2% shared at 1: 3 while 16.8% shared at 1: to more than 3. There were more computers in NEPAD schools since NEPAD project dealt with provision of computers to schools for ICT education while Cyber e-Schools provided only digital science materials to schools. The percentage access rate to computers was found to be very low with 31.1% of students reporting that they have less than 10% to computers, 23.0% indicated that it is between 11-25% accesses, 9.7% indicated an access rate of between 26-50%, 22.6% indicated between 51-75.5% accesses while those that had access to more than 76-100% were 13.7% learners. Table 4.17 shows computer access and sharing ratio in schools.

Table 4.17: Computer access and sharing ratio

	Computer Students Sharing Ratio				Approximate percentage of students that have access to the computers				
	1 to 1	1 to 2	1 to 3	More than 4	Less than 10%	11-25%	26-50%	51-75%	76-100%
Cyber e-Schools	5.7%	18.1%	9.2%	16.8%	17.2%	12.6%	5.2%	7.8%	7.4%
NEPAD	10.1%	18.1%	8.1%	13.9%	13.9%	10.4%	4.4%	14.8%	6.3%
All schools	15.9%	36.1%	17.3%	30.7%	31.1%	23.0%	9.7%	22.6%	13.7%

Source: field data

4.4.5 Problems encountered in the use of ICT facilities during learning

From a total number of respondents, 59.9% reported having experienced some problems while attempting to use the ICT facilities in the institutions. In this category, 50.7% had resolved to ask for assistance from the science teachers. Those who had not experienced any ICT related problems were 40.1% of the total sample. In this group, 49.3% of them had not asked for any assistance because they did not have any problems.

In the NEPAD schools, 35.6% of learners had experienced problems, 31.9% had asked for assistance, and 14.1% had no problems in the use of ICT facility in the schools and 18.2% of them did not ask for any assistance. Cyber e-Schools had 24.4% students who had experienced problems while attempting to use the ICT facilities in their schools and 18.8% of them had asked for assistance from their science teachers. About 25.9% of them had experienced no problems and 31.1% had not asked for any assistance. Table 4.18 shows the problems encountered by learners in the use of ICT facilities in schools.

Table 4.18: Problems encountered in the use of ICT facilities by learners

Institutional	Experienced problems while attempting to use ICT facilities at the school				Asked from assistance for library staff			
	YES		NO		YES		NO	
	freq.	%	Freq.	%	freq.	%	freq.	%
NEPAD Schools	362	35.6	144	14.1	182	31.9	300	18.2
Cyber e- School	248	24.4	264	25.9	308	18.8	176	31.1
Totals	610	59.9	408	40.1	490	50.7	476	49.3

Source: Field Data

4.4.6 The nature of problems experienced by the learners

The nature of the problems experienced by majority (26.0%) of the learners were lack of skills on how to use computer for the given science assignments. This resulted in calling their teachers regularly for assistances. Power blackouts also disrupted learning as was reported by 19.5% learners. None of the selected secondary schools had un-interrupted power supply (UPS). This resulted in numerous computer breakdown and machine performing poorly as was reported by 13.3% learners. Access to computer laboratories and limited number of available computers was reported by 17.4% respondents, poor Internet connectivity was cited by 14.7% while 9.1% indicated computer virus affected their science activities. Table 4.19 shows the nature of problems experienced by learners when using computers in learning science subjects.

Table 4.19: Nature of problems experienced

No		Frequency	Percentage (%)
1	Access to the lab and limited computers	98	11.5
2	Blackouts	101	12.0
3	Viruses	94	11.1
4	Poor Internet connectivity	151	17.7
5	Lack of skills to use computer	268	31.5
6	Faulty computers	138	16.2
		752	**100.0**

Source: field data

Students have also experienced many problems while trying to use the Internet services available in some of the sampled institutions. Lack of orientation of the learners by the teachers had made it difficult for them to access information that they required as was indicated by 41.9% of teachers. These resulted in wastage of time and frustration of the user's effort to benefit from the system.

About 16.1% of the respondents cited lack of enough resources in their schools. Some computers at schools were not functioning; others were infected by viruses while others were just obsolete. Other major problem experienced by students was poor connectivity to Internet. Sometimes computers could not connect to Internet at all and sometimes they were very slow to open a web site. This caused a lot of time wastage and frustration. Finally, 41.9% teachers cited that lack of resources at student's homes also caused some problems in the use of ICT in learning. Table 4.20 shows the problems encountered by students while using Internet facilities in schools.

Table 4.20: Problems encountered by students while using Internet facilities

	lack of resources in the school	lack of resources at students home environment	lack of experience with the use of Internet
Cyber School	9.7%	9.7%	29.0%
NEPAD	6.5%	32.3%	12.9%
All schools	16.1%	41.9%	41.9%

Source: field data

4.5 Teachers and Learners Training In ICT Skills

The third objective of this study was to assess how the training of the teachers and learners in ICT skills influenced the use of ICT in learning and teaching science subjects. This was done in order to answer the research question "How has the training of teachers and learners in ICT skills influenced use of ICT in teaching and learning science curriculum in the selected schools?" This section provides data that determines the extent to which teachers and learners were trained in ICT skills and its use in teaching and learning in the NEPAD and Cyber e-Schools programme. It also details the effect of ICT skills acquisition on use of ICT in teaching and learning science subjects. The areas of training explored were computer/ICT literacy, technical computer skills and collaborative training. This section focuses on the computer literacy skills possessed by teachers that would enable them to train learners and to use computers for teaching and learning in the NEPAD and Cyber e-Schools project. It outlines the skills required and teachers' responses to the skills provided.

4.5.1 Computer literacy training for teachers

The teachers were asked whether or not they were trained at all in ICT skills and in which application systems they were trained. Table 4.21 shows that majority 78.6% of the respondents were trained in one or more computer application programmes in the NEPAD and Cyber e-Schools projects while 19.0% were not. Table 4.21 shows access to ICT training before introduction of the e-learning or digital science program in schools.

Table 4.21: Access to ICT training before the introduction of e-learning/ digital science programme in the schools

		Freq.	%	Valid Percent
Valid	Yes	33	78.6	80.5
	No	8	19.0	19.5
	Total	41	97.6	100.0
Missing	System	1	2.4	
Total		42	100.0	

Source: field data

Discussions with teachers revealed that although most of them were trained, the training was poorly done resulting in most of them not possessing the required skills in technology to enable them become confident and creative in the use of ICT for teaching and learning. Over half of them had never had any training on the integration of technology into their teaching methods but only basic computer packages. Further discussions revealed that, some of them do not even understand the rationale for integrating ICT into learning and would rather prefer their present teaching styles to technology-oriented teaching techniques.

4.5.2 Computer application skills in which teachers were trained

The Table 4.22 shows that few respondents received training in many of the listed applications. Majority of them 57.3% had trained in word processing, Ms- Excel 46.4%, Internet 34.3%, Ms-PowerPoint 23.5%, Ms-Database 21.7%, and Desktop Publishing 21.2%, information skills/research 23.8%, programming 21.8% while 9.6% had trained in Web design skills.

Table 4.22: Teacher training in computer application skills

	Computer application skills which teachers were trained						Training programmes that were insufficiently trained, Yes – insufficiently - No- Sufficiently					
	Cyber e-Schools		NEPAD		All schools		Cyber e-Schools		NEPAD		All schools	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Ms Word	24.1%	26.2%	33.2%	16.2%	57.3%	42.4%	14.4%	35.4%	14.9%	35.3%	29.3%	70.7%
Ms Excel	15.9%	34.4%	30.5%	19.2%	46.4%	53.6%	15.3%	34.5%	16.6%	33.7%	31.9%	68.1%
Ms Power point	10.4%	40.0%	13.1%	36.6%	23.5%	76.5%	14.4%	35.3%	18.1%	32.2%	32.5%	67.5%
Internet Explorer/ www/E-mail	13.9%	36.3%	20.5%	29.4%	34.3%	65.7%	16.2%	33.6%	24.4%	25.8%	40.5%	59.5%
Microsoft Access/ Database	7.6%	42.7%	19.5%	30.1%	27.1%	72.9%	16.7%	33.2%	17.9%	32.2%	34.5%	65.5%
Desktop publishing	8.8%	41.4%	12.4%	37.3%	21.2%	78.8%	15.2%	34.6%	20.0%	30.2%	35.2%	64.8%
Web design	2.2%	48.0%	7.4%	42.4%	9.6%	90.4%	14.6%	35.3%	20.7%	29.4%	35.3%	64.7%
Information skills/ research	8.1%	42.0%	15.7%	34.2%	23.8%	76.2%	14.3%	35.4%	22.0%	28.2%	36.3%	63.7%
Programming skills	8.7%	41.5%	13.1%	36.7%	21.8%	78.2%	14.2%	35.7%	20.3%	29.8%	34.4%	65.6%

Though the teachers had access to some basic training on ICT skills, majority of them indicated that the training was not satisfactory to enable them to utilize it fully in teaching science subjects or teaching. These findings show that more training in application programmes is required to enable them to integrate ICT in their teaching work.

4.5.3 Training in ICT technical skills

Training in ICT technical skills is crucial for successful integration of ICT in teaching science subjects in order to enable teachers carry out simple repairs whenever the computers broke down during science lessons. This would facilitate provision of effective technical assistance to students on site. The Researcher made an effort to identify the technical skills that were provided to teachers in both NEPAD and Cyber e-Schools that would enable them to maintain computer systems in case they failed during science classes. The three main areas of computer systems explored were hardware, software management and networking. Table 4.23 provides an overview of the technical skills which teachers in NEPAD and Cyber e-Schools received in during the project. It shows the three main components of the technical training of NEPAD and Cyber e-Schools. It also, details the type of training and the particular program in which the teachers received training. As demonstrated in Table 4.23, the majority of the teachers 37.5% were trained to physically identify computer components and their functions. Few teachers were trained in different operating software's (windows 98, 95, 2000, and XP). Only 17.3% of the teachers had been trained on networking systems and procedures. This data show that only a small percentage of teachers had the necessary technical ICT skills.

Table 4.23: Teacher training in ICT technical skills

	ICT technical skills teachers were trained in						System they were trained unsatisfactory					
	Cyber e-Schools		**NEPAD**		**All schools**		**Cyber e-Schools**		**NEPAD**		**All schools**	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Hardware	24.9%	25.4%	37.6%	12.1%	62.5%	37.5%	10.2%	39.3%	12.7%	37.6%	22.9%	77.0%
OS-Win 98	36.4%	13.9%	24.3%	25.4%	60.7%	39.3%	11.5%	38.3%	12.7%	37.6%	24.2%	75.8%
OS-Win 95	41.9%	8.3%	34.4%	15.4%	76.3%	23.7%	12.5%	37.3%	18.8%	31.4%	31.3%	68.7%
OS-Win 2000	41.2%	8.9%	34.7%	15.2%	75.9%	24.1%	10.9%	38.9%	17.3%	32.9%	28.2%	71.8%
OS-Win NT/XP	38.9%	11.2%	33.4%	16.6%	72.2%	27.8%	11.9%	38.0%	18.0%	32.1%	29.9%	70.1%
Networking	42.7%	7.4%	40.0%	9.9%	82.7%	17.3%	11.7%	38.1%	18.7%	31.5%	30.4%	69.6%

The data in Table 4.23 show that majority of the teachers have received training in technical ICT skills unsatisfactory. The data further shows that training in hardware was unsatisfactorily covered followed by different operating software. Lack of appropriate technical knowledge in these areas has limited the teachers' ability to handle technical problems that may have arisen as they used computers in teaching and learning science subjects.

4.5.4 Teachers competence in ICT technical skills

As a results of unsatisfactory training in computer systems and technical skills, most (56.1%) of the teachers were unable to provide technical support needed in their schools computer system due to a lack of the required basic ICT technical skills. This might be due to the limited time provided during the training sessions. The aspect of training found to be most unsatisfactory was technical training in ICT skills. Perhaps the inadequacy of technical training led to most of them recommending it as the area that required further training. Teachers generally had embarked on training themselves, in one form or another, to keep abreast with the skills necessary to be able to use ICT tools in teaching. Table 4.24 shows the technical competence of teachers.

Table 4.24: Technical competence of teachers

	Yes		No	
	Freq.	%	Freq.	%
Cyber School	9	22.0	14	34.1
NEPAD	9	22.0	9	22.0
Total	18	43.9	23	56.1

During the interview sessions, teachers expressed lack of technical support and the indefinite time it takes for external technicians to resolve problems as dominant issues that prevented effective use of ICT in teaching and learning science subjects. At the time of the research, five schools had technical problems that had not been resolved for months. One school had no Internet and the others were having problems contacting the Internet service providers.

4.5.5 Training in the use of Digital Science software

For teachers to effectively integrate computer for teaching science subjects, they had first to receive training on how to use digital science software. This study show that majority of the teachers had not received training on use of digital science software while only 35.7% had received this type of training. The data in Table 4.25 shows the number of teachers who had been trained on how to use digital science software in teaching and learning science subjects.

Table 4.25: Training in the use of digital science software

	No	Yes
Cyber School	31.0%	23.8%
NEPAD	33.3%	11.9%
All schools	64.3%	35.7%

Source: field data

From the science teachers who had access training in use of digital science software learning materials for teaching science subjects, the majority had participated in training in more than one subject depending on their teaching subjects. Majority (47.6%) were trained on how to use chemistry program, while 38.1% had been trained in biology and physic software programmes consecutively. Only 23.8% of the teachers were trained on how to use mathematics software. Table 4.26 shows the digital science programs teachers have been trained in.

Table 4.26: Digital science software training for teachers per subject area

	Cyber e-Schools		NEPAD e-schools		All schools	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
Physics programme	21.4%	33.3%	16.7%	28.6	38.1%	61.9%
Chemistry programme	23.8%	31.0%	23.8%	21.4%	47.6%	52.4%
Biology programme	23.8%	31.0%	14.3%	31.0%	38.1%	61.9%
Mathematics programme	7.1%	47.6%	16.7%	28.6%	23.8%	76.2%

Source: field data

4.5.6 Training for Online-Collaborative School Projects

Collaborative training for teachers was crucial to enable them to train learners to undertake online education projects with their peers in other NEPAD and Cyber e-Schools. The question asked was whether teachers had been trained in collaborative skills. Majority of the teachers 81.0% had not received training on how to manage online collaborative school projects. Only 19.0% had received this type of training. Table 4.27 shows the training for online collaborative school projects teachers accessed.

Table 4.27: Online collaborative school projects

Types of schools	***Whether teachers have been trained in collaborative schools projects***	
	Yes	*No*
Cyber Schools	2.4%	*52.4%*
NEPAD e-schools	16.7%	*28.6%*
All schools	*19.0%*	*81.0%*

Source: field data

The research further revealed that very few teachers apart from science teachers had any other form of training in ICT related courses. Majority of them 73.2% indicated that less than two other non science teaching teachers were trained in their schools while 6.7% of the teachers indicated that their schools had more than five other teachers who were trained. For effective integration of ICT in teaching to take place, more teachers needed to be trained in ICT related courses.

The training varied in duration from two to ten days and from three to ten hours per day. The majority of teachers, that is, (80.6%) were trained between two and five hours per day, for between 10-20 days, 13.9% had trained for 3 days while 5.6% had trained for 2 days. NEPAD e-schools teachers had received more training days than the Cyber e-Schools. Moreover, concerning time allocated for training courses, none of the teachers from both NEPAD and Cyber e-Schools believed that it was enough to develop new ICT skills.

4.5.7 Ability to use ICT facilities in teaching and learning science subjects

Teachers reported major changes because of undertaking training courses. About half of the sampled teachers i.e. 55.0% were able to use the newly acquired ICT facilities in teaching and learning at some level with confidence. They were not avoiding work that involved use of computers and felt in control whenever they were using computers. Initially, they were apprehensive about using computers and would only use them when it was extremely necessary. Hence, they would avoid coming into contact with computers in their work and hesitated to use it for fear of making mistakes. Other benefits acquired due to the NEPAD and CSTS programs included the time to time access for engagement in collaborative projects which built confidence in teachers in use of ICT in teaching and learning science subjects.

About 10.0% of the teachers could engage in collaborative projects training from time to time while 35.0% teachers had the ability to deliver first level support and maintenance. The majority (32.2%) of those who could deliver first level and maintenance support were from Cyber Schools while NEPAD e-schools had majority of those that could not use these skills. The probable reason for this difference was that cyber CSTS trainers always took teachers through a training process in the use of digital science software during installation stage while NEPAD was basically involved in donating computers and other ICT facilities. However, the general level of competence in terms of repair and maintenance was still low. Table 4.28 shows teachers ability to use ICT facilities in teaching and learning science subjects.

Table 4.28: Teachers' ability to use ICT facilities in teaching and learning science subjects

Types of schools	ability-skills to deliver first level support and maintain		time-time to engage in collaborative projects		confidence-to operate without fear of damage	
	Freq.	%	Freq.	%	Freq.	%
Cyber Schools	9	22.5	0	0.0	13	32.5
NEPAD e-schools	5	12.5	4	10.0	8	22.5
All schools	14	35.0	4	10.0	21	55.0

The ability of teachers to use ICT as a tool of teaching science subjects was noted to be low with only 35.0% teachers being able while 65.0% were not able. This inability may have resulted from the level of skills acquired in terms of training and utilization. Some teachers proposed a reduction of teacher's workload in order to be able to prepare for their lessons on the computer. Teachers also proposed that there was needs for provisions of enough time to enable them teach the techniques they had learnt in using computers to students in an innovative and interesting way.

4.5.8 Duration of time teachers had computers for teaching science subjects

Use of ICT in teaching and learning science subjects was a new phenomenon in the selected schools. This study found that majority (79.5%) of those that had used computers for less than two years. Those that had used it for 2-5 years were 17.9, while the most experienced users (over 5 years) were 2.6%. Cyber schools had the greatest representation of teachers who had used ICT for teaching for a relatively shorter period. Table 4.29 shows duration teachers have been using computer as teaching and learning tool.

Table 4.29: Duration teachers have been using computers as a teaching and learning tool

	Less than 2 years		2-5 years		Over five years	
	Freq.	%	Freq.	%	Freq.	%
Cyber School	21	53.8	1	2.6	0	0.0
NEPAD	10	25.6	6	15.4	1	2.6
All schools	31	79.5	7	17.9	1	2.6

4.5.9 Training in Pedagogical skills

As the NEPAD and Cyber e-Schools programme sought to integrate computers into the teaching and learning process in schools it was necessary not only to train teachers in the ICT skills , but also in how to integrate the ICT in the teaching and learning process. This was crucial if the teachers were to use the computers in teaching science subjects. To this end, a number of questions were raised about teachers' professional knowledge and use of science teaching methods. The questions addressed pedagogical areas that are useful in teaching science subjects. These included method such as project based, constructivist, resource-based, authentic, research-based, student team and the systematized learning method.

The findings show that 42.9% of the teachers are familiar with the research-based teaching method, 45.2% were familiar with resource based teaching while 26.2% were familiar with project based learning and teaching methods. Less than half of the teachers were trained in only three teaching methods in the NEPAD and Cyber e-Schools programme. Only 9.5% teachers had knowledge of what the system-based method is, 45.2% of teachers were familiar with or exposed to the authentic learning method. Seven percent of teachers use the constructivist and 47.6% used student team methods in their schools.

Majority of the respondents indicated that only a few of the NEPAD and Cyber e-Schools trainers introduced the new teaching methods in their schools. An interesting observation was that the new methods which include the Constructivist, Resource Based, Authentic Learning and Student Team Method were not introduced in the schools as a result of the NEPAD and Cyber e-Schools projects. Another interesting observation is that the Research and Project Based Methods were being used by 9.5% of respondents while 14.3% of the teachers indicated that System Based Teaching Methods were introduced in the schools as result of use of ICT in teaching. Table 4.30 shows the use of pedagogical skills.

Table 4.30: Use of Pedagogical skills

	Familiar with		Before the projects		Training received		Introduced due to ICT	
	Yes	No	Yes	No	Yes	No	Yes	No
Research based	42.9%	57.1%	26.2%	73.8%	23.8%	76.2%	9.5%	90.5%
Constructivist	7.1%	92.9%	11.9%	88.1%	7.1%	92.9%		
Resource based	45.2%	54.8%	28.6%	71.4%	16.7%	83.3%		
Authentic learning	9.5%	90.5%	4.8%	95.2%	2.4%	97.6%		
Student team	47.6%	52.4%	40.5%	59.5%	12.0%	88.1%		
None	7.1%	92.9%	11.9%	88.1%	19.0%	81.0%		
Project based	26.2%	73.8%	33.3%	66.7%	26.2%	73.8%	9.5%	90.5%
Systems based	9.5%	90.5%	9.5%	90.5%	28.6%	71.4%	14.3%	85.7%

Source: field data

Most of the ICT related problems (61.5%) were not resolved by science teachers. Only 38.5% of students indicated that their problems were solved while others did not even ask for assistance. NEPAD schools had 22.2% of students whose problems were solved and 32.4% of these whole problems were not solved. Cyber e-Schools had 16.3% of solved cases and 29.1% of unsolved cases. Only 40.0% students were able to access information from the Internet while 60.0% could not. Of those that could access information from the Internet, many of them (61.3%) could not access information from the Internet without assistance. Only 38.7% of learners were able to access information from the Internet without assistance from either the teachers or computer technicians. Teachers also revealed that half of their learners cannot use the Internet without assistance and only 12 % of them said their learners could use the information on the Internet for learning without any help. Some of the teachers 40.0% indicated that lack of

ICT resources at learners' homes was responsible for the ICT integration problems. Forty percent said that the problem was a lack of ICT resources at the schools. The research further revealed that 13.3% of the learners could be able to carry out scientific experiments by use of computers or digital science materials (virtual lab) at a large extent while majority 86.7% could do it.

4.5.10 Level of computer literacy training among learners

The study investigated whether learners had any form of training in using computers before the introduction of ICT and digital science projects in their schools. The type of training and manner in which the training was managed was examined. Results from the study show that almost half of the learners (49.6%) had previously used computers before the ICT programs were started in their schools. However, majority (72.4%) had not received any computer training before the programmes were initiated in the schools. Table 4.31 shows computer literacy training for learners.

Table 4.31: Computer literacy training for learners

	Use of computer before the ICT or digital science was introduced in sampled schools				**Computer training received by learners before introduction of ICT program in schools**			
	Yes		Yes		Yes		*Yes*	
	Freq.	%	Fr	%	Fr	%	Fr	%
Cyber schools	247	23.9	276	26.7	126	12.2	*397*	*38.6*
NEPAD e-school	265	25.7	245	23.7	158	15.4	*348*	*33.8*
All Schools	***512***	***49.6***	***521***	***50.4***	***284***	***27.6***	***745***	***72.4***

Source: field data

Learners were trained in many of the application programs as shown by the data in the table 4.32. There was however, less training in Ms Power Point, Desktop publishing, Web design, Information skills, Web search and programming. NEPAD e-school learners had accessed more computer packages training than students in Cyber schools. Table

4.32 shows applications in which learners in NEPAD and Cyber e-schools learners were trained in.

Table 4.32: (a) Applications in which learners in NEPAD and Cyber e-Schools learners received/ training

	Applications in which learners in NEPAD and Cyber e-Schools learners received/ training											
	Cyber schools				NEPAD				All schools			
	Yes		No		Yes		No		Yes		No	
	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr
Ms Word	24.1%	247	26.2%	269	33.5%	340	16.2%	166	57.3%	587	42.4%	435
Ms Excel	15.9%	163	34.4%	352	30.5%	312	19.2%	197	46.4%	475	53.6%	549
Ms Power Point	10.4%	106	40.0%	409	13.1%	134	36.6%	374	23.5%	240	76.5%	783
Internet Explorer/ Web/E-mail	13.9%	142	36.3%	371	20.5%	209	29.4%	300	34.3%	351	65.7%	671
Ms Access/Database	7.6%	78	42.7%	438	19.5%	200	30.1%	309	27.1%	278	72.9%	747
Desktop publishing	8.8%	90	41.4%	424	12.4%	127	37.3%	382	21.2%	217	78.8%	806
Web design	2.2%	22	48.0%	491	7.4%	76	42.4%	433	9.6%	98	90.4%	924
Information skills/Research	8.1%	83	42.0%	428	15.7%	160	34.2%	349	23.8%	243	76.2%	777
Programming skills	8.7%	89	41.5%	425	13.1%	134	36.7%	375	21.8%	223	78.2%	800

Source: Field data

Table 4.32: (b) Evaluation of applications in which learners in NEPAD and Cyber e-Schools learners received training

	Applications in which learners in NEPAD and Cyber e-Schools learners received/ trained in unsatisfactory											
	Cyber schools				**NEPAD**				**All schools**			
	Yes		No		Yes		No		Yes		No	
	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr
Ms Word	14.4%	146	35.4%	359	14.9%	151	35.3%	358	29.3%	297	70.7%	717
Ms Excel	15.3%	155	34.5%	349	16.6%	168	33.7%	341	31.9%	323	68.1%	690
Ms Power Point	14.4%	146	35.3%	358	18.1%	183	32.2%	326	32.5%	329	67.5%	684
Internet Explorer/ WWW/E-mail	16.2%	164	33.6%	341	24.4%	247	25.8%	262	40.5%	411	59.5%	603
Ms Access/Database	16.7%	169	33.2%	337	17.9%	181	32.2%	327	34.5%	350	65.5%	664
Desktop publishing	15.2%	154	34.6%	350	20.0%	203	30.2%	306	35.2%	357	64.8%	656
Web design	14.6%	147	35.3%	356	20.7%	209	29.4%	296	35.3%	356	64.7%	652
Information skills/Research	14.3%	145	35.4%	359	22.0%	223	28.2%	286	36.3%	368	63.7%	645
Programming skills	14.2%	144	35.7%	363	20.3%	206	29.8%	303	34.4%	350	65.6%	666

Source: field data

The majority of learners (59.5%) were least satisfied with the training in Internet Explorer/ World Wide Web/E-mail, Ms Access/Database, Desktop publishing, Web design, Information skills/Research and Programming skills. They were most satisfied with training related to Ms Word, Ms Excel and Ms PowerPoint. These findings show that training in computer systems was very low with 37.5% having covered hardware lessons and operating system widows 98 which are outdated. There was less training in Windows 2000, Windows NT and the UNIX operating systems that are being used in many computers these days. Table 4.33 shows systems learners had been trained in and those that were trained unsatisfactory.

Table 4.33: (a) Evaluation of Systems training for Learners

	Cyber schools				NEPAD				All schools			
	Yes		No		Yes		No		Yes		No	
	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr
Hardware	24.9%	255	25.4%	260	12.1%	124	37.6%	385	37.5%	384	62.5%	640
OS Win 98	13.9%	142	36.4%	372	25.4%	259	24.3%	248	39.3%	401	60.7%	620
OS Win 95	8.3%	84	41.9%	427	15.4%	157	34.4%	350	23.7%	241	76.3%	777
OS Win 2000	8.9%	91	41.2%	420	15.2%	155	34.7%	354	24.1%	246	75.9%	774
OS Win NT/XP	11.2%	114	38.9%	396	16.6%	169	33.4%	340	27.8%	283	72.2%	736
OS Win UNIX	4.6%	47	45.5%	464	10.5%	107	39.4%	402	15.1%	154	84.9%	866
Networking	7.4%	75	42.7%	436	9.9%	101	40.0%	408	17.3%	176	82.7%	844

Table 4.33: (b) Computer Systems in which Learners did not receive satisfactory training

Hardware	**10.2%**	**103**	**39.4%**	**397**	**12.7%**	**128**	**37.6%**	**379**	**22.9%**	**231**	**77.0%**	**776**
OS Win 98	11.5%	116	38.3%	386	12.7%	128	37.6%	379	24.2%	244	75.8%	765
OS Win 95	12.5%	126	37.3%	376	18.8%	190	31.4%	317	31.3%	316	68.7%	693
OS Win 2000	10.9%	120	38.9%	383	17.3%	182	32.9%	324	28.2%	302	71.8%	707
OS Win NT/XP	11.9%	123	38.0%	381	18.0%	182	32.1%	325	29.9%	305	70.1%	706
OS Win UNIX	11.7%	118	38.1%	384	18.7%	189	31.5%	318	30.4%	307	69.6%	702
Networking	15.1%	152	34.7%	350	22.5%	227	27.8%	280	37.6%	379	62.4%	630

Source: field data

Training in computer systems generally was unsatisfactory. As in the Table 4.33, majority (37.6%) of the learners received unsatisfactory training in networking systems and procedures. This was followed by operating systems Win 95, win 2000, win NT/XP and Operating software's UNIX were also found to be covered unsatisfactorily during the training. The data collected showed that there was no consistency in the number of days during which learners were trained in ICT skills. While 34.2% of the learners were trained for less than two days, 7.8% were trained for 3 days, 7.8% for 4 days while 53.0% were trained for more than five days. From the data given in Table 4.34, it is observed that 14.9% of the learners had access to computer all the time for practicing, 35.6% had it sometimes, while 17.4% seldom had access to computers to practice on after training. About, 32.1% of learners had no access to computers after training.

Table 4.34: Evaluation of students' practical experience after training

	Cyber schools		NEPAD		All Schools	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
I never had a computer to practice on	48	4.7%	104	10.2%	152	14.9%
I seldom had a computer to practice on	134	13.2%	229	22.5%	363	35.6%
I sometimes had a computer to practice on	108	10.6%	69	6.8%	177	17.4%
I always had a computer to practice on	223	21.9%	104	10.2%	327	32.1%

Source: field data

4.5.11 Rating of computer training accessed by learners

Learners that had accessed training, majority (21.3%) did not receive satisfactory training in order to prepare them for the programs. Regarding the manner of training received the data in the Table 4.35 shows that 21.3% of the respondents indicated that they were not well trained for the integration of ICT in learning science subjects while 22.7% were not trained at all. Table 4.35 shows the computer level of training accessed by learners.

Table 4.35: Rating of computer level of training accessed by learners

	Cyber schools		NEPAD		All Schools	
	Freq.	%	Freq.	%	Freq.	%
I have had no training at all	95	7.9	114	14.8	209	22.7
Training has been unsatisfactory	154	10.1	209	11.2	362	21.3
I have been training fairly well	114	20.5	103	15.1	217	35.6
I have been trained very well	151	11.2	81	9.3	232	20.5

Source: field data

Regarding satisfaction with training received in use of computers for learning, 29.5% of learners indicated that they did not receive training at all, 23.7% were least unsatisfied with the training while 31.7% indicated that they were fairly trained. Only 15.2% of learners received training well. The Table 4.36 shows the extent to which learners were trained in the use of computers in learning science summarizes subject.

Table 4.36: Evaluation of training for learners in the use of computers for learning science subjects

	Cyber schools		NEPAD		All schools	
	Yes		Yes		Yes	
	Freq.	%	Freq.	%	Freq.	%
I have been trained very well	67	6.5	88	8.6	155	15.2
I have been trained fairly well	128	12.5	196	19.2	324	31.7
Training has been unsatisfactory	123	12.0	119	11.6	242	23.7
I have had no training at all	197	19.3	105	10.3	302	29.5

The students also had very positive attitude towards use of ICT in learning as was indicated by 22.2% of the teachers who stated that it was excellent while 66.7% indicated that it was good. However, 11.1% of the teachers indicated that student attitude towards use of ICT was fair. The positive attitude can enhance learning since students liked using ICT facilities. The analysis of students' perceived behaviour in terms of computer usage in learning science subjects indicated that 26.4% of them do not use computers at all, 33.2% used it not often while only 24.5% used a computer regularly. In spite of the fact that many of the students were aware of the usefulness of computers, many were still not using them.

4.6.0 Role of ICT infrastructure providers/ NEPAD and CSTS

The fourth objective of this study was to assess the roles of NEPAD and CSTS in provision of technical support and other ICT infrastructure. This also included provision of multimedia facilities, the type of technical support provided to schools and the role they played in providing Pedagogical skills necessary in supporting the integration of ICT in teaching science subjects.

4.6.1 NEPAD and Cyber e-Schools resource situation

This study investigated the provision of the prerequisite resources that would allow implementation of ICT in teaching and learning science subjects for both NEPAD and Cyber e-Schools programme. The questions posed among others were; what was the state of resources in NEPAD and Cyber e-Schools before and during the ICT programme in the schools. There was very limited provision of the requisite resources that supported ICT integration in these schools before the implementation NEPAD and Cyber e-Schools projects. The Table 4.36 shows that 7.1% schools had a library or media centre, 21.4% had a computer laboratory, 21.4% had school librarian/media teacher, 7.1% had access to Internet while none of the schools had network controller. The implementation of the NEPAD and Cyber e-Schools programmes triggered improvements in the resource situation. Table 4.37 shows ICT resource situation in schools.

Table 4.37: ICT resource situation

		Before the program		After the program	
		Yes	No	Yes	No
Computer laboratory	Cyber e-Schools	14.3%	40.5%	54.8%	
	NEPAD e-Schools	7.1%	38.1%	45.2%	
	All schools	21.4%	78.6%	100.0%	
Library/media Centre	Cyber e-Schools	0.0%	54.8%	4.8%	50.0%
	NEPAD e-Schools	7.1%	38.1%	23.8%	21.4%
	All schools	7.1%	92.9%	28.6%	71.4%
School librarian/media teacher	Cyber e-Schools	4.8%	50.0%	4.8%	50.0%
	NEPAD e-Schools	16.7%	28.6%	26.2%	19.0%
	All schools	21.4%	78.6%	31.0%	69.0%
School Multimedia Centre	Cyber e-Schools		54.8%	.0%	54.8%
	NEPAD e-Schools		45.2%	11.9%	33.3%
	All schools		100.0%	11.9%	88.1%
Internet access	Cyber e-Schools	7.1%	47.6%	11.9%	42.9%
	NEPAD e-Schools	0.0%	45.2%	14.3%	31.0%
	All schools	7.1%	92.9%	26.2%	73.8%
Network controller	Cyber e-Schools		54.8%	0	54.8%
	NEPAD e-Schools		45.2%	4.8%	40.5%
	All schools		100.0%	4.8%	95.2%
There were no resources available	Cyber e-Schools		54.8%		
	NEPAD e-Schools		45.2%		
	All schools		100.0%		

Source: field data

4.6.2 Sources of Computers to Support ICT in Schools

Refurbished computers appeared to be the most feasible option for providing e-schools with computers. Out of twelve secondary schools that participated in this study, eleven had received their computers as a donation from NGOs, Government (MoE) and NEPAD while one school had bought its own computers. Majority of the donated computers were old as indicated by 92.5% respondents. Refurbished computers have extremely high level of failure and require constant repairs, maintenance, replacement and updates.

This process of maintaining the functionality of ICT infrastructure in schools was frustrating and a barrier to the use of ICT in teaching science curriculum in these schools.

The process of obtaining any form of support was lengthy, time consuming and services were never availed to the schools at the time when they were most needed. Even machines that were still under warranty had to go through stringent bureaucratic channels before they were serviced. Only 7.5% of the sampled secondary school had received technical assistant that included computers that were not functioning. Table 4.38 shows the sources of ICT infrastructure support received by schools.

Table 4.38:` Sources of Computers to Support ICT in Schools

		Yes	No
Donation of old computers	Cyber e-Schools	45.0%	3.3%
	NEPAD e-Schools	47.5%	4.2%
	All schools	92.5%	7.5%
Donation of New computers	Cyber e-Schools	7.5%	45.0%
	NEPAD e-Schools	5.0%	42.5%
	All schools	12.5%	87.5%
Technical support	Cyber e-Schools	5.0%	47.5%
	NEPAD e-Schools	2.5%	45.0%
	All schools	7.5%	92.5%

4.6.3 Other Education Technologies Available In NEPAD and Cyber E-Schools

The study investigated whether or not there were other education technology facilities present at NEPAD and Cyber e-Schools during the ICT programme. It is thought that the presence of other technology would influence the general use of ICT in teaching and learning science subjects in e-schools. Teachers were asked to state which other education technology existed in their schools before and after the introduction of ICT project. Television and video machines top the list of multimedia equipment that was available in the e-schools before introduction ICT projects. Data projectors and slide projectors were not available in any of the selected schools before introduction of ICT. It is noted that most of the multimedia equipment had existed in the NEPAD and Cyber e-Schools before the projects. However, it is interesting to observe that during the projects, the number of equipment had increased, except for radios. Table 4.39 details other educational technologies available in NEPAD and Cyber E-Schools.

Table 4.39:`Education Technology in School for the purpose of teaching

		Currently available		Available before the ICT program in schools	
		Yes	No	Yes	No
TVs	Cyber e-Schools	35.0%	17.5%	30.0%	22.5%
	NEPAD e-Schools	42.5%	5.0%	40.0%	7.5%
	All schools	77.5%	22.5%	70.0%	30.0%
Video machines	Cyber e-Schools	17.5%	35.0%	22.5%	30.0%
	NEPAD e-Schools	30.0%	17.5%	22.5%	25.0%
	All schools	47.5%	52.5%	45.0%	55.0%
Radio	Cyber e-Schools	22.5%	30.0%	30.0%	22.5%
	NEPAD e-Schools	40.0%	7.5%	42.5%	5.0%
	All schools	62.5%	37.5%	72.5%	27.5%
Data projectors	Cyber e-Schools	15.0%	37.5%		52.5%
	NEPAD e-Schools	27.5%	20.0%		47.5%
	All schools	42.5%	57.5%		100.0%
Tape recorders	Cyber e-Schools	30.0%	22.5%	25.0%	27.5%
	NEPAD e-Schools	32.5%	15.0%	10.0%	37.5%
	All schools	62.5%	37.5%	35.0%	65.0%
Video recorder	Cyber e-Schools	7.5%	45.0%	7.5%	45.0%
	NEPAD e-Schools	27.5%	20.0%	.0%	47.5%
	All schools	35.0%	65.0%	7.5%	92.5%
Over head projectors	Cyber e-Schools	17.5%	35.0%	2.5%	50.0%
	NEPAD e-Schools	30.0%	17.5%	.0%	47.5%
	All schools	47.5%	52.5%	2.5%	97.5%
Slide/tape projectors	Cyber e-Schools	5.0%	47.5%		52.5%
	NEPAD e-Schools	2.5%	45.0%		47.5%
	All schools	7.5%	92.5%		100.0%
Talking books	Cyber e-Schools	2.5%	50.0%	.0%	52.5%
	NEPAD e-Schools	7.5%	40.0%	2.5%	45.0%
	All schools	10.0%	90.0%	2.5%	97.5%
Sensors	Cyber e-Schools	5.0%	47.5%		52.5%
	NEPAD e-Schools	0.0%	47.5%		47.5%
	All schools	5.0%	95.0%		100.0%
Database software's	Cyber e-Schools	5.0%	47.5%		52.5%
	NEPAD e-Schools	22.5%	25.0%		47.5%
	All schools	27.5%	72.5%		100.0%
Spreadsheets	Cyber e-Schools	7.5%	45.0%		52.5%
	NEPAD e-Schools	20.0%	27.5%		47.5%
	All schools	27.5%	72.5%		100.0%

4.6.4 Rating of digital science materials

The digital science materials included science software CDs, students workbook; class materials for practical work, the trainer's manual (lesson guides) and interactive widows training program and optional flip chart. With regard to the perceived usefulness of the digital science materials, 10.3% of learners rated the materials very poor and 8.4% rated them as poor 44.7% agreed that the materials were very useful and 36.5% indicated that they were useful and could enhance their performance in science subjects. They indicated that the layout was excellent. The materials responded to the learners' science learning needs. This is because the information was simple to understand and related well to their science curriculum. Therefore, most of the students observed that computers could enhance their performance in science subjects. Table 4.40 shows the rating of digital science materials.

Table 4.40: Rating of digital science materials

		Cyber School		NEPAD		All schools	
No	Rating	Freq.	%	Freq.	%	Freq.	%
1	Very useful	196	19.8	246	24.9	442	44.7
2	Useful	195	19.7	166	16.8	361	36.5
3	Poorly	52	5.3	31	3.1	83	8.4
4	Very poorly	43	4.4	59	6.0	102	10.3

Source: field data

4.6.5 Support received by schools during NEPAD and Cyber e-schools projects

An investigation was carried out to assess what support the e-schools had received during the period that the projects were implemented in view of their novelty and what were the consequences of lack of support. Though many teachers had received a wide range of assistance during the NEPAD and Cyber e-Schools projects, the support was noted to be at very minimal level. The Table 4.40 shows that 38.1% of the respondents received support in learning strategies and 16.7% received support in collaborative planning. The Table 4.41 also shows that 9.5% were supported emotionally, 7.1% received mentorship and 45.2% received some technical support. Sixteen point seven per cent 16.7% of the teachers were unfortunately not given any form of support at all.

Table 4.41: Support received by NEPAD and Cyber e-Schools

		Yes		No	
		Freq.	%	Freq.	%
	Cyber e-Schools	3	7.1	20	47.6
	NEPAD e-Schools	1	2.4	18	42.9
Emotional	All schools	4	9.5	38	90.5
	Cyber e-Schools	11	26.2	12	28.6
	NEPAD e-Schools	8	19.0	11	26.2
Technical	All schools	19	45.2	23	54.8
	Cyber e-Schools	9	21.4	14	33.3
	NEPAD e-Schools	7	16.7	12	28.6
Learning strategies	All schools	16	38.1	26	61.9
	Cyber e-Schools	2	4.8	21	50.0
	NEPAD e-Schools	5	11.9	14	33.3
Collaborative planning	All schools	7	16.7	35	83.3
	Cyber e-Schools	2	4.8	21	50.0
	NEPAD e-Schools	1	2.4	18	42.9
Mentorship	All schools	3	7.1	39	92.9
	Cyber e-Schools	3	7.1	20	47.6
	NEPAD e-Schools	4	9.5	15	35.7
None	All schools	7	16.7	35	83.3

Source: field data

4.6.6 Reasons cited for lack of support

The reason cited by majority of the teachers (47.5%) for not accessing any support was due to distance from source of help to the needy schools. In addition, 4.8% indicated that their request for assistance was not acted upon. However, 27.5% had not requested for any assistance although they had many technological problems in their schools. Table 4.42 shows reasons cited for lack of access to assistance.

Table 4.42:` Reasons cited for lack of access to support

		Yes	No
Not asked for support	Cyber e-Schools	12.5%	40.0%
	NEPAD e-Schools	15.0%	32.5%
	All schools	27.5%	72.5%
Not willing to help despite asking	Cyber e-Schools	4.8%	50.0%
	NEPAD e-Schools	.0%	45.2%
	All schools	4.8%	95.2%
Schools are far away from source of assistance.	Cyber e-Schools	25.0%	27.5%
	NEPAD e-Schools	22.5%	25.0%
	All schools	47.5%	52.5%

4.6.7 Teacher's use of computers prior to implementation of ICT programmes in the schools

Majority of the sampled teachers (80.5%) had not used computers prior to the implementation of ICT programme in their schools while 19.5% had used computers. For them to be able to use computers after the ICT program introduction in their schools, they had to first train on application and ICT technical skills.

These findings show that, the programs were revelation for teachers most of whom accessed and used computers for the first time during the implementation of ICT programs in their schools. Table 4.43 shows the number of teachers who had experience in use of computer before the ICT program introduction in their schools.

Table 4.43: Use of computers prior to the implementation of the ICT programme in schools

	2 days		Descriptive Statistics				
	Yes	No	N	Minimum	Maximum	Mean	S.D
Cyber School	14.6%	41.5%	41	1.00	2.00	1.1951	.40122
NEPAD	4.9%	39.0%					
Total	19.5%	80.5%					

4.6.8 Advantages of using computers in learning science subjects.

The present study elicited from learners their views about the advantages of using ICT in learning science subjects. Learners were asked to state how the computers had helped them to improve their studies in science subjects. From a list provided in the Table 4.43 the majority (27.5%) felt that the computer has helped them to learn, followed by 21.8% of learners' who felt that computers provided much information necessary in the science subjects. In addition, 21.2% indicated that they were now able to develop effective learning skills, 11.6% were able to concentrate on what they were doing and the same number was able to communicate and share information with other students. In addition, 6.2% learners indicated that they have a lot of fun when working with computers. Table 4.44 shows advantages of using computers for education.

Table 4.44: Education advantages of using computers

		Cyber School		NEPAD		All schools	
		Freq.	%	Freq.	%	Freq.	%
a)	I am able to concentrate on what I was doing at a time	76	7.6	40	4.0	116	11.6
b)	I enjoy using the computer to learn	130	13.0	144	14.4	274	27.5
c)	I am able to communicate and share knowledge	45	4.5	71	7.1	116	11.6
d)	I am able to access lots of information	101	10.1	117	11.7	218	21.8
e)	I am able to develop learning skills	109	10.9	103	10.3	212	21.2
f)	I have a lot of fun working with computers	37	3.7	25	2.5	62	6.2

The research sought to explore possible links between the use of ICT in teaching and learning and achievement by students in national tests and examinations. The teachers were asked to indicate whether they have noted some improvement in academic performance since the introduction of ICT in their schools. The results show that, there was perceived improvement in academic performance especially in cyber e-schools where 18.6% teachers indicated that the performance was good and 28.3% citing that it was average. In all schools, 31.8% indicated that performance was good, 48.8% stated that it was average with only 19.4% indicating that it was poor. Discussions with teachers revealed that the number of poor performing students in sciences was decreasing especially in Cyber e-schools. The researcher also observed that Cyber e- schools had better and customized digital science resource materials compared to the NEPAD e-schools.

In this investigation, 60.0% teachers indicated that though ICT projects in schools had many challenges, their impact in terms of student's performance in science subjects has been witnessed. Although NEPAD e-Schools had science software for teaching science subjects, performance in their schools in science related subjects was low as opposed to Cyber e-school. However, 40.0% indicated that this has not been realized. The average performance of students in courses that use digital science materials or computers was reported to be good by 42.9% teachers, 48.6% indicated that it was fair while 8.6% indicated that it was poor.

Overall, teachers from both NEPAD e-Schools and Cyber Schools reported highly positive impact of use of ICT in teaching and learning science subjects. The data in the table below show that students had observed some level of improvements in terms of their academic performance in science subjects due to use ICT in their schools. They felt that the performance was low before the introduction of ICT in their schools. Table 4.45 shows the impact of ICT in science education.

Table 4.45: The Impact of ICT in science Education

	Whether there is significant improvement in performance in science subjects following introduction of ICT based teaching / learning		Average performance of students in courses that use digital science materials or computers		
	Yes	No	Poor	Fair	Good
NEPAD e- Schools	17.1%	28.6%	2.9%	20.0%	28.6%
Cyber Schools	42.9%	11.4%	5.7%	28.6%	14.3%
All Schools	60.0%	40.0%	8.6%	48.6%	42.9%

Source: field data

4.6.9 Benefits of the NEPAD and Cyber e-Schools projects

The study investigated the benefits and challenges that NEPAD and Cyber e-Schools were experiencing. Many of the teachers (92.5%) felt that the programmes had introduced modern approaches to learning and teaching science subjects. Sixty five percent (65.0%) of the teachers felt that the programs had introduced new challenges to their professional development as science teachers. Fifty percent (50%) felt that ICT could become part of the schools science education and learning environment. Others felt that it had enabled them to develop themselves as far as the new approach to teaching science subjects was concerned. They also indicated that use of ICT in teaching had equipped them with information communication skills and their learners had acquired ICT skills that would be useful in their work places in future. Table 4.46 shows the benefits of ICT programme in schools.

Table 4.46: Benefits of ICT programme in schools

		Cyber e-School	NEPAD	All schools
1	Introduced modern approaches to learning and teaching science subjects	47.5%	45.0%	92.5%
2	Introduced new insights into science education	12.5%	17.5%	30.0%
3	Introduced new challenges to my professional dev. as a science teacher	42.5%	22.5%	65.0%
4	Ushered me to the global educational arena	17.5%	20.0%	37.5%
5	Enable me to develop myself as far as the new approach to teaching science subjects is concerned	22.5%	17.5%	40.0%
6	Enable me to equip myself with computer and information skills	20.0%	20.0%	40.0%
7	The school has received international recognition(been put on the Internet: (information superhighway)	7.5%	12.5%	20.0%
8	Modern educational equipment has become part of the schools science teaching and learning environment	22.5%	27.5%	50.0%
9	Students acquire skills that they will use in their work places	12.5%	27.5%	40.0%
10	Students performance in sciences has improved	17.5%	12.5%	30.0%

Source: field data

Many learners 36.9% believe that learning computer programming will help them derive the full benefits of learning with computers. In addition, 37.1% of the learners indicated that more practice of the correct use of applications would help them to derive full benefits from the computers. However, the majority (48.0%) of the learners believe that introducing computer studies as a subject will help them improve the use of ICT in learning science subjects and the utilization of computers in schools. The learners 43% indicated that learning computer programming would help them derive the full benefits of learning with computers. Only ten learners (24%) indicated that more practice on the correct use of applications would help learners to derive full benefits from the computer. The majority (69%) felt that introducing computer studies as a subject will help improve the utilization of computers in learning in the schools.

4.6.10 Impact of use of ICT Teaching Science Subjects in NEPAD and Cyber e-schools

The four ICT factors addressed in this study influenced use of ICT in teaching science subjects in the selected schools. The research also particularly focused on the use of Internet by teachers and students, advantages of using ICT for teaching and learning science subjects, and solicited views of teachers on student's performance as a result of using ICT in learning. The research found that, few teachers to source for essential information, which was often incorporated into lessons to make them interesting and authentic, commonly use Internet.

Very often, teachers designed activities that required students to access information from the Internet. These activities are either guided where a list of websites is provided for students or open- ended where students do their own search on the Internet for the necessary information based on a given task. For instance, a number of teachers incorporated biographical information on famous mathematicians and scientists from the Internet into their lessons to stimulate interest in a particular scientific principle, techniques or even development of scientific methods. Students visited websites containing everyday applications of Science to gain better understanding scientific concepts and procedures. However, 57.1% teachers could not access the Internet.

About 58.8% respondents said the Internet was often not available while 41.2% indicated that they do not have sufficient ICT skills to enable them use Internet teaching resources. These groups of teachers could not use software or word-processing facilities. They were not obviously able to obtain information from the Internet for any teaching purposes. To address the problem of teachers inability to use Internet due to lack of ICT skills, teachers recommended in-service training in computer skills.

4.6.11 Challenges posed by projects to e-Schools

The teachers selected from a list of what were the challenges regarding the ICT project to them and to their schools. The majority of respondents (89.7%) felt as that the projects had given them extra work and added responsibility, without additional remuneration. 51% felt that it had brought conflict with other members of staff as they scrambled to access the limited ICT resources. Interestingly, 25.6% felt that they could not perform normal teaching duties while 12.8% had experienced conflicts with their Principals because of the programmes. More than a half of the respondents (70%) saw the projects as an expensive venture to undertake. Many respondents (75%) see the cost of maintaining the computer system as a major problem in the future while 62.5% felt that students spend more time in the computer room at the expense of other subjects. Table 4.47 shows the challenges posed by ICT projects in e-schools.

Table 4.47: Challenges posed by ICT project in schools

	Cyber e-School	NEPAD	All schools
More work and added responsibility without additional pay	46.2%	43.6%	89.7%
Inability to discharge normal teaching duties	5.1%	20.5%	25.6%
Causes conflict with other members of staff	23.1%	28.2%	51.3%
Causes conflict with school principal	5.1%	7.7%	12.8%
Students spend more time in the computer room at the expense of other examination subjects	30.0%	32.5%	62.5%
It's an expensive venture	42.5%	27.5%	70.0%

While teachers recognized the potential of integration of ICT in teaching and learning science subjects in secondary schools, they expressed the following challenges. Majority of teachers (87.5%) indicated that the high cost of maintenance of ICT infrastructure might negatively affect the effective implementation of the programmes. This is because schools did not have enough funds to sustain the ICT programmes in the e-schools. 82.5% of the teachers felt that since the programmes relied heavily on the use of refurbished computers, this could lead to e-waste that may negatively affect the environment in their schools.

Majority of teachers (82.5%) continued use of ICT in teaching could result in replacement of teachers in future. About 77.5% indicated that it will result in a society that has moral decay due to uncontrolled Internet interference in what is to be learnt. Also, 55.0% felt that teachers who have less ICT skills and knowledge would frustrate the system while 50.0% had health concerns that may result from use of ICT facilities. Table 4.48 shows the future problems posed by ICT in schools.

Table 4.48: Future Problems posed by ICT usage in schools

	All schools	
	Freq.	%
High cost of maintenance	35	87.5
Moral decay	28	77.0
Teachers who will not update their skills and knowledge will frustrate the system	22	55.0
Health concerns-spending too much time on computer	20	50.0
Replacement of teachers	35	87.5
e-waste	7	17.5

During discussions with science teachers in this research, it was found that, the biggest problem with encouraging teachers to use ICT in their teaching was the lack of suitable access to ICT infrastructure. Many of the selected secondary schools had very poor ICT resources that included refurbished computers and lack of suitable software applications. Electricity and Internet connections were also expensive and frequently unreliable. The Science teachers complained that access to computer rooms was restricted to certain times. They found this to be inconvenient. This is because of having to share access to a limited number of computers with students, administrators and other teachers. This negatively affected their science lesson preparation and hence the use of ICT in teaching. Therefore, poor provision of ICT resources, unreliable Internet connection, lack of knowledge on how to browse on the Web and lack of provision of software made teachers to express some concerns of their failure to use ICT in teaching science subjects.

This investigation further established that ICT training and utilization in the selected institutions is hindered by a number of limitations. The initial high costs in installing computers in the sampled schools caused a delay in acquiring the required number of computers. This included the cost of purchasing both hardware and software. The number of users was too high compared to the number of computers that were available are in good working condition in most of the sampled schools. This made users to queue for long hours to try and get a chance to use the system. This study established that some secondary schools have very old computers which could not accommodate the new updated programmes. Other computers had broken down due to lack of qualified technicians to repair, update them and remove computer viruses. 57.5% teachers cited this problem. In all the schools, teachers mentioned that the government does not provide funds for repair and maintenance of the ICT infrastructure.

In 76.5% schools, Internet services sorely depended on telephone lines. None of the schools had broad band wireless connections. About 29.4% secondary schools were using dial-up connection using telephone lines, 23.5% had integrated services digital network ISDN while 47.1% uses ADSL lease line.. The telephone cables transmit data from one computer to another, yet the telecommunication system in the country continues to be inefficient. One telephone line that is used as a bus to carry Internet data maybe so loaded as to make computer respond slowly in opening some websites. Sometimes telephone services breakdown and the company takes time to effect repairs. This causes institutions to stay for long without Internet services. As long as poor telecommunication services exist, extensive networking would be greatly hampered. Old computers that had slow speeds and capacity were also slow in connecting to Internet even if other conditions were favourable. The bandwidth given by Internet Service Providers (ISP) was very small such that it could not accommodate the many users trying to access information at the same time. This was cited by 77.5% of the respondents.

The findings of the investigation were that effective use of computers in teaching and learning science subjects was inhibited by indifference to utilization of ICT by some teachers. Teachers lacked enthusiasm due to either being fearful or pessimistic about what ICT can achieve in teaching and learning science subjects. Some science teachers were afraid of dealing with computers because they believed that computer technology is too sophisticated for them to learn how to use it for teaching. In other situations, they tended to think that automation would cost them their jobs. They imagined that their roles would be taken over by machines and hence be rendered jobless. Some science teachers, due to their advanced age, felt threatened and embarrassed to be seen learning with younger people and did not want to join them in the same computer rooms.

Through observation and discussions with science teachers, it was found that there was inadequate numbers of computer tables, CD-ROMs and other computer peripherals. In some institutions, the computer rooms were too small to accommodate large number of users. Most respondents indicated that, lack of suitable space to install ICT related facilities was a major barrier to ICT utilization in teaching. Power blackout was reported by the respondents as being a big challenge to integration of ICT in teaching science subjects in the schools. The researcher also observed that some science teachers and students were not enjoying the benefits of ICT facilities available in their institutions because they were ignorant and not fully aware of what ICT could do in improving learning and teaching processes in their schools.

Section B – Test of Hypotheses

This section presents the results of hypotheses analysis and interpretations of relationships among various variables in the study as has been conceptualized in the research objectives. Chie squire and regression analysis were used to test the hypotheses. Relationship is statistically significant at p = 0.05 (or 95% confidence level). Following this tread, results from each significant is reported.

4.7.0 School environment and use of ICT in teaching and learning

The relationship among the various variables contained in objective one were analyzed in order to establish how the school environment influences the use of ICT in the teaching and learning science subjects. The independent variables in objective one are the location of school, mode of Internet connection, power supply and physical environment inside the computer laboratories while the dependent variable is use of ICT in teaching science subjects. The following hypotheses derived from variables in objective one are presented as follows:

H1a: The location of schools does not influence the use of ICT in teaching science subjects.

The results from analysis shows that there is a statistical significant positive relationship between where the school is located and use of ICT for teaching and learning science subjects ($r^2 = 0.431$, P-value 0.023) less than <0.05. The assumption was that secondary schools located in urban areas have higher chances of accessing electricity, Internet, modern computer labs and better support from school principles hence they able to integrate ICT in teaching science subject more effectively. The null hypothesis (H0) that there is no association between location of school and use of ICT in teaching science subjects was rejected. This results may be explained by the facts that different location of schools (urban, Semi urban and rural areas) had different challenges affecting them for example power supply and Internet connection. This is depicted in Table 4.49

Table 4.49: Location of schools and use of computers for teaching science subjects

Relationship test	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R^2	F Change	df1	df2	Sig. F Change
Relationship between the location of the school and use of ICT in teaching science subjects	.656(a)	.431	.265	.6612		2.605	9	1.139	.023

Source: field data

H1b: The access to Internet services in schools does not influence the use of ICT in teaching science subjects

The findings of this study shows that access to Internet services has a weak statistically significant relationship with utilization of ICT in teaching science subjects ($r^2 = 0.590$ P-value 0.000) less than <0.05 (Table 4.50). The assumption was that since the Internet is a source of a lot of e-learning science materials and collaborative learning, its availability will therefore influence its use for teaching and learning.

Table 4.50: Access to Internet services in schools and use of computers for teaching science subjects

Relationship test	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
Relationship between access to Internet services in schools and use of ICT in teaching science subjects	.768(a)	.590	.471	.3262	.590	4.960	9	31	.000

H1c: The power supply does not influence the use of ICT in teaching and learning science subjects

The source of power supply (electricity) has a strong positive significant relationship with use of ICT in teaching science subjects p-value = 0.050 (Table 4.51). The null hypothesis (H0) that there is no association between availability of reliable power supply to schools and use of ICT in teaching science subjects was rejected. These findings mean that even if all other ICT infrastructures were in place without electricity, learning using ICT will not take place. The science teachers will therefore most likely revert to the conventional mode of teaching (chalk and talk). The unreliability of electricity was cited by 39.8% teachers as being an impediment to their effective use of ICT in teaching and learning science subjects.

4.51 Power supply and use of ICT in teaching and learning science subjects

Relationship test	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
Relationship between power supply and use of ICT for teaching and learning	.701(a)	.492	.334	.40989	.492	3.120	9	29	.050

Source: field data

H1d: The physical environment inside the computer laboratories does not influence the use of ICT in teaching and learning science subjects.

Various physical environment factors inside computer laboratory were found to have a significant relationship with use of ICT in teaching science subjects. Lighting in laboratory had (r^2 = 0.515, P-value 0.003), ventilation had (r^2=0.636 p-value 0.000), noise level had a relationship at p-Value 0.000 (Table 4.52). However, the furniture in the laboratory had no relationship (r2=0.370 p-vale 0.071 which is >0.05. The assumption of this study was that computer laboratory which had good lighting, well ventilated, good furniture and reduced noise will influence teaching and learning. Table 4.52 shows the relationship between physical environment inside computer laboratory and use of ICT for teaching and learning. The null hypothesis (H0) that there is no association between physical environment inside a computer laboratory and use of ICT in teaching science subjects was rejected. These factors should be taken into account while setting up a computer laboratory since they seem to affect ICT aided learning or teaching at significant level.

Table 4.52: Physical environment inside computer laboratories and use of ICT

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	P-Value
Lighting	.718(a)	.515	.375	.62245	.515	3.662	9	31	.003
ventilation	.797(a)	.636	.530	.70876	.636	6.018	9	31	.000
furniture	.608(a)	.370	.187	.92194	.370	2.020	9	31	.071
noise level	.801(a)	.642	.538	.61962	.642	6.170	9	31	.000

Source: field data

As demonstrated above, the hypothesis that school environment is significantly related to use of ICT in ICT in teaching science subject in NEPAD and Cyber e-schools was accepted. The suggestion here is that the location of the schools, access to Internet, availability of electricity supply and the physical environment within computer labs play a major role for effective utilization of ICT in teaching and learning science subjects.

4.8 Effect of access to ICT and use of ICT in teaching and learning

To establish how access to computers and other ICT infrastructure (including multimedia facilities) affect the use of ICT in the teaching and learning strategies used in the science curriculum, the following hypotheses were analysed and the results obtained are presented in Tables 4.53, 4.54, 4.55 and 4.56.

H2a: There number of working computers does not influence the use of ICT for teaching and learning science subjects

Table 4.51 indicates that there is a weak statistical significant association between the number of working computers and their utilization in teaching and learning science subjects (r^2=0.596 p-value 0.000 less than <0.05 (Table 4.53). It was assumed that available working computers will influence use of ICT in teaching science subjects. The null hypothesis (H0) that there is no association between number of working computers and use of ICT in teaching science subjects was rejected. This suggests that the number of available working computers influence use of ICT in teaching science subjects. Therefore, for effective utilization of ICT in teaching and learning science subjects, the number of working computers needs to be frequently maintained through repairs and in good time.

Table 4.53: Access and use of ICT

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**				
					R Square Change	F Change	df1	df2	P-Value
Relationship between number of working computers and use of ICT for teaching and learning science subjects	.772(a)	.596	.479	.77022	.596	5.089	9	31	.000

H2b: The network connection does not influence the use of ICT in teaching and learning science subjects

This study found that there is a relationship between computer networks and use of ICT in teaching and learning (r^2=0.500 p-value 0.010). Relationship is statistically significant at p = 0.05 (or 95% confidence level). The assumption made in this study is that availability of computer network will influence use of ICT in teaching science subjects since some science digital materials are normally installed in one computer (server) and shared out to other computers through intra netting. The null hypothesis (H0) that there is no relationship between computer network and use of ICT in teaching science subjects was rejected. The results obtained are presented in Table 4.54.

Table 4.54: Computer networks and use of ICT

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	P-Value
Relationship between computer networks and use of ICT for teaching and learning science subjects	.707(a)	.500	.339	.37358	.500	3.111	9	28	.010

H2c: The availability of file server does not influence the use of ICT in teaching and learning science subjects.

The study revealed that there is a weak relationship between availability of file server and utilization of ICT in teaching (r^2=0.635, p-value 0.001 (<0.05). The null hypothesis (H0) that there is no relationship between the availability of file server and use of ICT for teaching and learning science subjects was therefore rejected. The assumption was that since file servers are used to installing digital science materials which is shared to other computers, lack of it may impede effective use of ICT in teaching science subjects. Table 4.55 shows the relationship between access to ICT infrastructure including multimedia facilities and use of ICT in teaching and learning science curriculum.

Table 4.55: File server and use of ICT

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	P-Value
Relationship between availability of file server and use of ICT for teaching and learning science subjects	.797(a)	.635	.509	.30763	.635	5.036	9	26	.001

H2d: The student's computer sharing ratio does not influence the use of ICT in learning and teaching science subjects..

Chi-square tests revealed that there is a statistical significant relationship between use of computers for learning and students sharing ratio (P-value 0.000) > p = 0.05 (or 95% confidence level). The null hypothesis (H0) that there is no relationship between the use of computer for learning purposes and student's computer sharing ratio was rejected. It was assumed that for purposes of efficiency and effectiveness in using ICT in teaching science curriculum in schools, computers for both teachers and students should be available most preferably at 1:1 ratio so as to increase learner's concentration and capacity to absorb all learning materials thus positively influencing use of ICT in teaching and learning. This finding suggests that for effective utilization of ICT in teaching and learning, the number of computers need to be at a level of 1:1 ratio. Table 4.56 shows the relationship between use of computer for learning purpose and student's computer sharing ratio.

Table 4.56: Student's computer sharing ratio and use of computer for learning purposes

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	39.151(a)	4	.000
Likelihood Ratio	38.847	4	.000
Linear-by-Linear Association	.550	1	.458
N of Valid Cases	988		

Source: field data

The assumption for this hypothesis is that school with many working computers may enhance their utilization in teaching and learning science subjects. For purposes of efficiency and effectiveness in using ICT in teaching science curriculum in schools, computers for both teachers and students should be available most preferably at 1:1 ratio. This is assumed to increase learner's concentration and capacity to absorb all learning materials.

4.9 Teachers and learners acquisition of basic ICT skills and use of ICT in learning and teaching

This involved an analysis of how the training of the teachers and learners in ICT skills influenced the use of ICT in learning and teaching science subjects. The dependent variable is use of ICT in teaching and learning and the independent variable includes access to ICT training skills, duration of training ICT skills, teacher's technical competence and training in pedagogical skills. The results obtained are presented in Tables 4.57, 4.58, 4.59 and 4.60.

H3a: The level of ICT trainings teachers and learners received does not influence use of ICT in teaching science subjects in NEPAD and Cyber e-schools.

This study found that, there was a weak relationship between training in ICT skills and use of ICT for teaching and learning science subjects (r^2=0.496, p-value 0.007 (<0.05) Table 4.57. The null hypothesis (H0) that there the level of ICT skills trainings teachers and learners received does not influence use of ICT in teaching science subjects in NEPAD and Cyber e-schools was therefore rejected. The assumption for this was that training in acquisition of ICT skills could influence its use in teaching science subjects, as teachers are likely to have competence and confidence in using ICT facilities in their schools. This suggests that training in acquisition of ICT skills can influence its use in teaching science subjects, as teachers are likely to have confidence in using it.

Table 4.57: In ICT skills and utilization of ICT for teaching and learning

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
Relationship between training in ICT skills and utilization of ICT for teaching and learning science subjects	.705(a)	.496	.345	.32775	.496	3.287	9	30	.007

Source: field data

H3b: The duration of ICT skills training does not influence the use of ICT in teaching and learning science subjects.

The number of days teachers spent in ICT skills training was found to significantly affects utilization of ICT in teaching and learning science subjects (r^2=0.440, p-value = 0.049 (<0.05) Table 4.58. The null hypothesis (H0) that there is no significant relationship between duration of ICT skills training and the use of ICT in teaching and learning science subjects was therefore rejected. The assumption was that the length of training period would increase conceptualizing of the new ICT skills and thus influence use of ICT in teaching and learning. Most teachers were trained for less than two week. This may have influenced their low integration of ICT in teaching science subjects.

4.58: **Duration of ICT skills training and the use of ICT**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
Relationship between duration of ICT training and the use of digital science materials					R Square Change	F Change	df1	df2	Sig. F Change
	.664(a)	.440	.247	.81652	.440	2.273	9	26	.049

Source: field data

H3c: The teacher's technical competence does not influence their use of ICT for teaching and learning science subjects.

The study found that teachers technical competence affect their utilization of ICT in teaching science subjects (r^2=0.694 p=value 0.000 (<0.05) (Table 4.59). The null hypothesis (H0) that there is no positive relationship between teacher's technical competence and their use of ICT for teaching and learning was rejected. The assumption in this hypothesis was that if teachers acquire ICT technical skills, they can use ICT facilities more effectively in teaching and learning science subjects since they will be able to fix minor ICT technical ICT problems rather than wait for external support.

Lack of technical competence therefore impede effective utilization of ICT since a lot of time will be lost as school seek for technical assistance which may not be forthcoming thus influencing use of ICT in teaching and learning. The majority of teachers in this study could not offer first level technical support in case computers in their schools failed.

4.59: Teacher's technical competence and use of ICT

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
Relationship between teacher's ICT technical competence and use of ICT for teaching and learning	.833(a)	.694	.602	.31791	.694	7.551	9	30	.000

Source: field data

H3d: The training in pedagogical skills does not influence the use of ICT for teaching and learning

The study assessed the relationship between various pedagogical skills and their relationship to integration of ICT in teaching science subjects. One assumption of the investigation was that the use of ICT in teaching science subjects was to some extent influenced by access to various pedagogical skills. The research findings show that there is a degree of positive relationship between various pedagogical skills and their effects in integration in teaching science subjects.

There was a significant weak relationship between collaborative schools projects (P-value = 0.006), strong relationship between project based (P-value 0.29), students team had (p-value 0.015), research based at (p-value 0.019), while resource based and system based had each (P-value 0.000). However, there was no relationship between authentic learning (P-value 0.135) and constructivist (P-value 0.249) > 0.05 (Table 4.60). In this study, most science teachers were not familiar with the above pedagogical skills while others had never heard of them. This may have reduced their level of integration of ICT in teaching science subjects. The null hypothesis (H0) that there is no positive relationship between training in pedagogical skills and use of ICT for teaching and learning was rejected. Table 4.60 shows the relationship between training in pedagogical skills and use of ICT for teaching and learning.

Table 4.60: Training in pedagogical skills and use of ICT for teaching and learning

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
collaborative school projects	.700(a)	.491	.343	.32526	.491	3.318	9	31	.006
Project based	.647(a)	.419	.250	.38849	.419	2.481	9	31	.029
Constructivist	.532(a)	.283	.075	.25359	.283	1.359	9	31	.248
Resource Based	.769(a)	.591	.472	.27672	.591	4.978	9	31	.000
Authentic Learning	.573(a)	.328	.134	.14537	.328	1.685	9	31	.135
Student team	.671(a)	.450	.291	.25299	.450	2.822	9	31	.015
Research based	.663(a)	.440	.278	.36950	.440	2.709	9	31	.019
System based	.777(a)	.604	.490	.32908	.604	5.264	9	31	.000

Source: field data

4.10 The role of ICT infrastructure providers in the use of ICT in teaching and learning

The roles of infrastructures providers and their support in the e-schools were analysed and presented in Table 4.61 and 4.62.

H4a: The role of ICT infrastructure providers does not influence the use of ICT in teaching and learning science subjects

This study found that, there was a relationship between ICT infrastructure providers and use of ICT for teaching science subjects r=0.566 p-value >0.008 less than <0.05 (Table 61). The null hypothesis (H0) that there is no relationship between ICT infrastructure providers and use of ICT in teaching and learning science subjects was rejected. This may be explained by the fact that, both types of schools were using ICT for teaching science subjects at different levels while NEPAD e-schools were using encyclopaedias CDs, Cyber schools were using well-developed digital science learning materials from CSTS. The assumption is that teachers from schools with good ICT resources will use ICT more effectively than resource-deprived schools.

Table 4.61: Roles of infrastructure providers and use of ICT in teaching and learning science subjects

Tests	R	R^2	Under-standardized Coefficients		Standardized Coefficients	t	P
Relationship between ICT infrastructure providers and use of ICT in teaching and learning science subjects	**1.1.3**	**1.1.4**	**B**	**Std. error**	**Beta**	**1.1.5**	**1.1.6**
	0.566	.321	0.950	0.334	0.146	2.847	.008

H4b: The technical support received by the e-Schools does not influence the use of ICT in teaching and learning.

The study further revealed that, there was no relationship between type of schools and the kind of support that they received (r^2 0.134 p-value 0.406) which is more than >0.05 (Table 4.62). The null hypothesis (H0) that there is no relationship between technical supports received the projects and Cyber e-Schools and use of ICT in teaching and learning was accepted. This is explained by the fact that, no significant support was given by the infrastructure providers except either by donation of computers to NEPAD e-schools or installation of digital science materials in Cyber School.

The assumption was that the kind and magnitude of technical support received by school would influence the use of ICT in teaching and learning. However, teachers in NEPAD e-schools tended to be relatively less concerned with what computers in schools were being used for. In total, the data suggests that approximately less than a half of the teachers across the two school categories reported that they did not get other ICT related support. Table 4.62 shows the relationship between infrastructures' providers, technical and pedagogical support and use of ICT in teaching and learning science subjects.

Table 4.62: Infrastructure providers, technical and pedagogical support and use of ICT in teaching and learning science subjects

Tests	R	R^2	Under-standardized Coefficients		Standardized Coefficients	t	P
			B	**Std. error**	**Beta**		
Relationship between technical Support, pedagogical training received by teachers in e-Schools and use of ICT in teaching and learning.	0.366	0.134	.833	.991	-0.250	.841	.406

Source: field data

4.11 Summary

This chapter presented the quantitative data of the study using frequencies and percentages. Use of ICT for teaching science subjects was found to be low due to various factors that impend effective utilization as outlined in the chapter. The study hypotheses were tested using the regression analysis and Chi-square measure to test for statistical significance of association between the dependent and independent variables. The aim was to establish whether the two variables were associated in a statistically significant way. The acceptance level was set at p = 0.05 level. The research findings were then discussed including an examination of the factors influencing the use of ICT in teaching and learning as per the study objectives.

Technical and pedagogical ICT-competence, attendance at ICT-related professional development courses, location of the schools, availability of computer laboratories or multimedia resources, access to Internet services, power supply, physical environment of computer laboratory and access to information from Internet or multimedia were significantly and positively correlated to use of ICT. In addition, the number of working computers, availability of file server, student's computer sharing ratio, ICT skills, duration of ICT training, teacher's ability to use multimedia facilities and pedagogical skills were also significantly and positively correlated to use of ICT in teaching and learning science subjects. Of all the personal characteristics of the science teacher, pedagogical ICT-skills were the best positive predictor of teachers' pedagogical adoption of ICT, a finding triangulating well with the observation that the teachers were more willing to attend pedagogical than technical professional-development activities on ICT-use.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

The general objective of this study was to investigate the factors influencing effective use of ICT in learning and teaching science subjects in Cyber school Technology Solution (CSTS) e-schools (Cyber e-schools) and New Partnership for Africa Development e-schools (NEPAD e-schools) in Kenya. Four objectives were formulated to achieve this goal. The first objective was to investigate how the school environment influenced the use of ICT in teaching and learning science subjects. In order to achieve this objective, a number of research questions and hypotheses were proposed. They focused on the location of schools (urban, semi urban or rural schools). Physical aspects such as the environment of the computer laboratory (lighting, ventilation, furniture, noise level and space) were also considered to be important variables. The power supply, availability of computer network and how supportive schools principals were for ICT projects in schools, were also investigated.

The study also sought to investigate how access to computers and other ICT infrastructure including multimedia facilities affect the use of ICT in teaching and learning science curriculum. In order to achieve this objective, several questions and hypothesis were postulated. They focused on the number of working computers, availability of computers peripherals, computer-sharing ratio among the learners, availability of file server, availability of computer network connection and number of computers connected to Internet. The investigation also sought to find out whether students had problems with use of computer, the extent to which they were able to access information from the Internet and carry out scientific experiments. The third objective was to assess how the training of the teachers and learners in ICT skills influenced the use of ICT in learning and teaching science subjects. In an attempt to achieve this objective, respondents were asked various questions regarding their use of ICT.

Lastly, the study sought to identify the role of ICT infrastructure providers in the use of ICT in teaching and learning science subjects in NEPAD and Cyber e-Schools. This was achieved by asking questions and proposing hypotheses about ICT infrastructures provided to the schools and ICT technical and pedagogical support rendered to schools by NEPAD and Cyber e-schools. The benefits and challenges of the ICT programme in schools were also evaluated at this stage.

The study posed fifteen hypotheses. All hypotheses were tested for significance using the regression analysis and Chi-square test at $p = 0.05$ level of significance or 95% confidence level, as discussed in Chapter four of this study. The findings of the hypotheses complemented the findings of the descriptive statistics and observations made during the study.

5.1 Summary of Research Findings

This section presents a summary of the research findings which are presented according to the sub-themes that were generated from reviewing the literature related to the study.

Table 5.1: Factors influencing ICT use in teaching and learning science curriculum

	Objectives	Research Questions	Variables/ Indicators// Dimensions	Hypothesis	Results	Remarks
1	To establish how the school' environment influences the use of ICT in teaching and learning science subjects.	What are the specific environmental characteristics of the schools, which have influenced the use of ICT in teaching science curriculum in the selected schools?	Location- rural, urban and semi urban	H1a: The location of schools does not influence use of ICT in teaching science subjects	R=.0.656, R^2=0.431, P-value .023	Strong relationship exists (Hypothesis rejected)
			Mode of Internet connection	H1b: The access to Internet services in schools does not influence use of ICT in teaching science subjects	R=0. 768, R^2=0.590, P-value 0. 000	Weak relationship exists (Hypothesis rejected)
			Supply of electricity in schools	H1c: The power supply does not influence the use of ICT in teaching and learning science subjects	R=0. 701, R2=.492, P-value 0.050	Strong relationship exists (Hypothesis rejected)
			Physical environment of computer laboratory in terms of lighting and ventilation	H1d: The physical environment inside the computer laboratories does not influence use of ICT in teaching and learning science subjects	R=0.718, R^2= 0.375, P-value 0. 003	Strong relationship exists (Hypothesis rejected)
2	To determine how access to computers and other ICT infrastructure including multimedia facilities affect the use of ICT in teaching and learning science curriculum.	How has the access to computers and other ICT infrastructure including multimedia facilities influenced use of ICT in teaching science curriculum?	Number of functioning computers	H2a: The number of working computers does not influence use of ICT for teaching and learning science subjects	R=0. 772, R^2= 0. 596, P-value 0.000	Weak relationship exists (Hypothesis rejected))
			Network connection	H2b: The network connection does not influence use of ICT in teaching and learning science subjects	R=0. 707, R^2= 0. 500, P-value 0.010	Weak relationship exists (Hypothesis rejected)
			Availability of file server	H2c: The availability of file server does not influence and the use of ICT for teaching and learning science subjects	R=0.797, R^2=0.635, P-value 0.001	Weak relationship exists (Hypothesis rejected)
			Computer sharing ratio.	H2d: The students' computer sharing ratio does not influence and the use of computer for learning purposes	Pearson's R =-0.024, P-value 0.000	Weak relationship exists (Hypothesis rejected)
3	To verify how the training of teachers and learners in ICT skills influenced the use of ICT in learning and teaching science subjects.	How has the training of teachers and learners in ICT skills influenced use of ICT in teaching and learning science curriculum in the selected schools?	Types of ICT systems trained Training in the use of digital science materials	H3a: The level of ICT trainings teachers and learners received does not influence use of ICT in teaching science subjects in NEPAD and Cyber e-schools.	R=0. 705, R^2= 0.345, P-value 0.007	Weak relationship exists (Hypothesis rejected)

			Duration of ICT training	H3b: The duration of ICT skills training does not influence the use of ICT in teaching and learning science subjects.	R=0.664, R^2= 0.664, P-value 0.049	Strong relationship exists (Hypothesis rejected)
			Technical skills	H3c: The teachers' technical competence does not influence their use of ICT for teaching and learning.	R=0.833, R^2= 0.694, P-value 0.000	Weak relationship exists rejected)
			Training in pedagogical in use of ICT in teaching science subjects	H3d: The training in pedagogical skills does not influence the use of ICT for teaching and learning science subjects	R=0.647, R^2=0.419, P-value = 0.029	Strong relationship exists (Hypothesis rejected)
4	To identify the role of ICT infrastructure providers in use of ICT in the teaching and learning science subjects in NEPAD and Cyber e-Schools.	How are the current roles of ICT infrastructure providers influencing use of ICT in learning and teaching science subjects in NEPAD and Cyber e-schools?	Capacity to implement projects	H4a: The role of ICT infrastructure providers does not influence the use of ICT in teaching and learning science subjects	R=0.566 R^2=.321 Beta=0.1.46, t=2.847 P-0.008	Weak relationship exists (Hypothesis rejected)
			Technical support	H4b: The technical support received by e-Schools does not influence the use of ICT in teaching and learning.	R=0.366, R^2=.0.134 Beta=-0.250, t=.841	No relationship exists (Hypothesis accepted)

5.2 Discussions

Several factors determine the success or failure of use of ICT in teaching and learning science subjects in schools. Some of these factors have been the basis of the present study. They include access to ICT infrastructure resources in terms of quantity and quality, Internet connectivity, availability and quality of digital science software, power supply and continuous training programmes for teachers and learners in ICT skills necessary for learning and teaching purposes. The following section discusses the research findings and subsequently compares these findings with related literature.

5.2.1 Characteristics of schools that influence the use of ICT in the curriculum for teaching and learning science

The locations of the schools had an influence in availability of ICT prerequisites for example electricity, telecommunication, and Internet connectivity. Over half of the sampled secondary schools 54.8% were located in semi-urban areas 36.8% were in urban areas while 8.4% were in rural areas. The test results revealed an association of r^2=0.431, P-value .023 which is significant with regard to the study's set level of significance (p = 0.05). Consequently, the conclusion was that the location of school influenced use of ICT in teaching science subjects.

The location of computers in schools also determined the ease of access by teachers and students. In particular, teachers and students' use of ICT for teaching and learning was restricted if the access was confined to laboratories. Also, test results showed that the various physical environment factors inside computer laboratory influenced use of ICT in teaching and learning (r^2= 0.375, P-value 0. 003). These factors include good lighting, well ventilation, and suitable furniture and reduced noise levels.

Secondary schools are not given adequate funds to provide furniture, laboratories and adequate classrooms, let alone being given adequate funds ICT infrastructures. Due to the lack of adequate power supply especially in rural areas, secondary schools located in these areas had no access to the Internet and hence, could be perpetually isolated excluded from the world's information superhighway (Paltridge, 1996).

Access to the Internet greatly varied amongst the selected schools. The majority of sampled secondary schools (46.2%) had only one computer connected to the Internet. About 7.7% had two computers connected to the Internet; 15.4% had three connected to the Internet; while 30.8% indicated that they had an average of 20 computers connected, which translated to all computers in the laboratories connected to Internet. Nevertheless, teachers complained about the quality of Internet speed. Consequently, this hampered the use of computers for Internet searches for science information or accomplishment of the assignments given to students by their science teachers. The association between access to Internet services in schools and use of ICT in teaching science subjects was found to be significant at $p = 0.000$ and was below the study's level of significance (0.05). The conclusion drawn from this is that access to Internet services influences use of ICT in teaching science subjects. This was due to the fact that Internet was a source of a lot of e-learning science materials and collaborative learning.

The association between power supply and the use of ICT in teaching and learning was found to be significant at $p = 0.050$, which fell below the study's level of significance (0.05). The conclusion drawn from this is that access to power supply strongly influences the use of ICT in teaching and learning science subjects. These findings mean that even if all other ICT infrastructures were in place without electricity, learning using ICT would still not take place. The science teachers would therefore be likely to revert back to the conventional mode of teaching ('chalk and talk' method). The unreliability of electricity was cited by 39.8% teachers as being an impediment to their effective use of ICT in teaching and learning science subjects.

The association between various physical environments inside computer laboratories and use of ICT in teaching and learning was as follows. Lighting in laboratory had ($r^2 = 0.515$, P-value 0.003), ventilation had ($r^2=0.636$ p-value 0.000), while noise level had a relationship at p-Value 0.000 and was below the study's level of significance (0.05). The conclusion drawn from this is that computer lab which had good lighting, well ventilated, good furniture and reduced noise would influence teaching and learning. Consequently, there was a strong relationship between physical environment inside computer laboratory and use of ICT in teaching and learning.

The school leadership can play a crucial role in ICT integration across education and could hinder or facilitate schools adoption of ICT in learning and teaching (Earley et al., 2004: Fink, 2005: Fullan, 2003: Reynolds et al., 2000: Richardson, 2005: Tyack et al., 1994). This study found that since the majority of principals in the selected schools did not use the Internet, they provided minimal support towards the integration of ICT in their schools. This was due to their ignorance of the role ICT could play in learning and teaching. Moreover, lack of funds to support ICT programmes also played a significant part for the negative attitude portrayed by principals towards ICT usage in teaching and learning science curriculum in the e-schools. According to Reynolds and Teddlie (2000), the powerful role of school leadership is able not only to filter educational interventions mandated by the upper levels of the educational system, but also it has significant influence on various school conditions.

Fullan (1997) stresses the crucial role that school principal's play in creating a climate for teachers to be more effective and efficient. Furthermore, according to Leithwood et al, 1992; MaCBeath et al, 2002, the quality of leadership makes a difference between the success and failure of schools. Fidler, 1997 notes that the school leadership has a strong impact on the feelings and actions of school members as they implement reforms and thrive to achieve goals.

There are four main avenues of principals' influence within schools: purposes and goals, school structure, social networks, people, and organisational culture (Hallinger and Heck, 1998). Therefore, principals do not only influence individuals in schools, but their powerful impact reaches the entire organisational system of schools. In addition, principals can decide on how to steer organisational change and how to support teachers during their implementation of ICT (European SchoolNet, 2005). Therefore, continuous leadership commitment is one of the major leveraging factors for the adoption of ICT by school members (Baylor et al., 2002; Rathbun, 2004).They articulate visions for their schools and influence their staff to implement these visions (Mullen et al., 2002). Furthermore, a good principal can create a vision that is shared by school members and makes them strive to achieve mutual goals (Leithwood et al., 1992).

Knowledge and skills of school leaders can also play a major role in their support of and enthusiasm about ICT integration in schools. Richardson (2005) indicated that one of the main obstacles to the effective integration of ICT is the lack of engagement and confidence of school leaders in leading the development of ICT in their schools.

Therefore, he stressed the importance of training school leaders in order to raise their "e-confidence".

5.2.3 Access to Computers and Other ICT Infrastructure Including Multimedia Facilities

The present study found that access to working computers was a major problem. The number of computers to users/students in all the sampled secondary schools was too high for the available facilities to cope with. Half of the sampled schools (50.0%) had less than 20 computers, 30.0% had between 21-30 computers, while 10.0% had between 31- 40 and above. On average, there were 10 computers per school that were selected for this study and even then not all the computers were in working condition. The association between number of working computers and use of ICT in teaching and learning was found to be significant at p =0.000, which fell below the study's level of significance (0.05). it is important to note that access to computers in classrooms is important for the successful adoption of computers for instructional purposes (Sahin and Thompson, 2006: Tella et al, 2007). According to Medlin (2001) and Surendra (2001), the accessibility and availability of computers was an important factor affecting the use of computers for instructional purposes.

Research by Rogers (2003) indicates that trainability and operability are the two attributes of an innovation that might increase the rate of use of ICT in teaching and learning. If science teachers are aware of computer technologies and have opportunity to access computers, their level of integrating technology into their teaching methodology may increase. The conclusion drawn from this is that the number of available and well maintained computers would influence use of ICT in teaching science subjects. Hence, the number of working computers should be maintained on a regular basis for the effective utilization of ICT in teaching and learning science subjects.

There were inadequate numbers of computer tables, chairs and CD-ROMs. Some of the schools had converted classrooms into computer laboratories, which in most cases, were found to be too small to accommodate large numbers of users. The association between network connection and use of ICT in teaching and learning was found to be significant at p =0.010, which fell below the study's level of significance (0.05) or 95% confidence level. The conclusion drawn from this is that the availability of computer network will influence the use of ICT in teaching science subjects, since some science digital materials were normally installed in a server linked to other computers through the intranet.

The association between the availability of file servers and the use of ICT in teaching and learning was found to be significant at p =0.010, which was below the study's level of significance (0.05) or 95% confidence level. The conclusion drawn from this is that file server influenced use of ICT in teaching and learning. This is because the servers were used in the installation of digital science materials, which were subsequently shared out with other computers. Consequently, the lack of servers may impede the effective use of ICT in teaching science subjects.

This study shows that most NEPAD and Cyber e-Schools have fewer than the minimum required information resources such as computer in networked laboratories, Internet access, libraries, multimedia centres and ICT teachers necessary to effect computer-based science education. It is also evident that there are only a few functional computers at NEPAD and Cyber e-Schools. Furthermore, software and poor Internet access made it impossible for any effective collaborative projects to take place.

The association between computer sharing ratio and the use of ICT in teaching and learning was found to be significant at p =0.000, which fell below the study's level of significance (0.05) or 95% confidence level. The conclusion drawn from this is that the use of computers for learning and the degree to which students shared computers influences the efficient and effective use of ICT in teaching science curriculum in schools.

The quantity issue must be examined side by side with the quality issue. Apparently, there is a need for technical support and maintenance as soon as computers arrive into schools (Granger et al., 2002: Hakkarainen et al., 2001). Technical assistance is a key factor for implementing new innovations (Fullan, 1982). Unreliable ICT in schools is found to be "the best innovation killer" (Hepp et al., 2004). There is a significant positive correlation between the technical assistance received by schools and their progress in implementing ICT (Byrom, 2001).

Other education technologies such as television, video, radio and overhead projectors, which support technology-based science education, existed only in few schools. All the twelve secondary schools (six NEPAD and six Cyber e-Schools respectively) sampled in this study had computer laboratories. However, none of the sampled schools had a multimedia centre or network controller. There was an average of ten computers per school and an average of five computers with CD-ROM drives. A number of schools still had computers, with Windows 98 operating systems, which Microsoft software vendors no longer support. While many schools have television sets, few schools have slide or data projectors.

Only 7.1% schools indicated that they have regular Internet access. This is significant because Internet access is a basic factor for teaching and learning science subject's and collaborative online learning with other learners across the NEPAD and Cyber e-Schools. In addition, in three quarters of the sampled secondary schools, only 2-4 computers were connected to the Internet. This is a serious hindrance for collaborative projects. In some schools, the researcher found that the computer connected to the Internet was located in the principal's office, which means that no collaborative learning could take place in such a school. It is also important to point out that approximately 57.1% of the sampled teachers did not use information from the Internet for teaching and learning because the Internet connection was often unavailable. These findings are not different from the case of Mozambique, where McGhee and Kozma (2001) found 65% of teachers reported that the lack of Internet access was a major barrier to the implementation of the ICT in teaching and learning programmes in schools.

A number of researchers have established that an adequate school resource environment, with the appropriate logistics, infrastructure and personnel is necessary for good-quality ICT education (Linddell et al, 1990: Radebe, 1997: Gordon, 1997: Todd, 1997: SAIDE, 1998). A study by Liddell et al. (1990) proposes that the provision of good educational materials is the most cost-effective way of improving educational quality. Addo (1999) found that the adequacy of infrastructure and logistics in schools is conditional to the availability and use of ICT for teaching and learning. This study found that important elements for utilizing ICT in education are a school computer laboratory, a school library, a school librarian/media teacher, electricity, telephone facilities and security against theft. Consequently, education technology should not be viewed in isolation but rather be viewed from the broader societal distribution of resources.

Half of the teachers indicated that the provision of better computers and training in ICT technical skills training would improve the use of computers in teaching and learning in the NEPAD and Cyber e-Schools. This reinforces the point made earlier concerning refurbished computers. Most learners held the view that the introduction of computer studies as a subject in schools will help improve the rate of utilization of the computer as a learning tool and hence improve the NEPAD and Cyber e-Schools programmes. It is assumed that the introduction of computer studies will make provision for dedicated teachers. This will increase the capacity in terms of time and personnel for computer-related subjects and issues, not only in NEPAD and Cyber e-Schools, but also in the future of integration of ICT in teaching and learning science subjects in Kenya.

A large body of literature indicates that access to ICT is a prerequisite for its integration and adoption of ICT by teachers and students in schools (Byrom, 2001: Dimmock, 2000: Downes et al., 2001: Granger et al., 2002: Hakkarainen et al., 2001: Hepp et al., 2004). Although there is no consensus in the literature about the ideal ratio of computers to students in schools, the provision of adequate access to computers is important (Dimmock, 2000). For purposes of efficiency and effectiveness in using ICT in teaching science curriculum in schools, computers for both teachers and students should be available most preferably at 1:1 ratio. This is assumed to increase learner's concentration and capacity to absorb all learning materials. The overall ratio of students to computers in all the participating schools stood at 18.1: 1. However, this ratio greatly varied from school to school. An average of only ten working computers to a NEPAD and Cyber e-Schools was considered a limiting number. The study shows that many learners took part in the science classes, which means that there were more than two learners to a computer. Lack of adequate hardware was therefore a major barrier to the NEPAD and Cyber e-Schools programmes.

The initial high costs involved in installing computers delayed the acquisition of the required number of computers in the schools. This includes the cost of purchasing both hardware and software. This resulted in dependency on donations of old computers from well-wishers. The number of students was higher compared to the number of computers that were available and were in good working condition in most of the selected secondary schools. This makes students queue for long hours to try to get a chance to use the computer mostly for Internet searches for learning science materials. This study established that some schools were provided with very old computers that could not accommodate the newly updated programmes. Other computers had broken down due to lack of a computer technician to repair, update them or remove computers viruses.

5.2.4 Training of teachers and learners in ICT skills and use of ICT in the curriculum for teaching and learning science in the selected schools

In order to use information and communication technology (ICT) in secondary schools, there is need for locally trained ICT technicians to install, maintain and support these systems. This study found that there is acute shortage of trained personnel in application software, operating systems, network administration and local technicians to ICT facilities. This study further found that teachers and learners in the NEPAD and Cyber e-Schools were inadequately trained in computer application programmes, collaborative school projects, database systems and programming. They were unsatisfied with the time allocated to the training. The association between duration of ICT skills training and the use of ICT in teaching and learning was found to be significant at $p = 0.049$, which was below the study's level of significance (0.05) or 95% confidence level. The conclusion drawn from this is that the time-span of training period would increase conceptualizing of the new ICT skills and thus influence use of ICT in teaching and learning.

The study also showed that none of the teachers had a computer to practice on in the use of ICT skills acquired during and after the training sessions. It was observed in this study that, lack of technical training for teachers would hamper on the success of the programmes. This is because NEPAD and Cyber e-Schools computers were predominantly refurbished and required constant maintenance. The lack of training in ICT technical skills among the teachers prevented the programmes from progressing to the levels of integrating ICT into the teaching and learning processes. In some schools, it was considered necessary to outsource ICT technical functions from private service providers. This had high cost implications for schools in the already impoverished environments.

These findings concur with those presented by Kiarie (2007) where he stated that most secondary school teachers lack the skills to comprehensively utilize technology in curriculum implementation hence the traditional chalk and duster approach still dominates in secondary school pedagogy. Consequently, secondary school teachers must be trained on educational technology and the integration of ICT into classroom teaching. According to Carlson and Firpo (2001), teachers need tools, techniques, and assistance that can help them develop ICT based projects and activities designed to raise the level of teaching.

The findings of this investigation revealed that not all teachers involved in the NEPAD and Cyber e-Schools programme were trained and of those trained most had no computers to practice on. Most teachers did not receive effective training in computer applications and collaborative school science projects. Microsoft Word was the only computer application found to be most satisfactory covered during training.

The association between ICT training and use of ICT in teaching and learning was found to be significant at p =0.007 and was below the study's level of significance (0.05) or 95% confidence level. The study test results revealed that possession of ICT skills enhances integration of ICT in teaching science subjects. This finding concurs with previous studies including Mwanja (2001) and Wakanyasi (2002). Moreover, it is also supported by theoretical assertions made by Kibera (1997) who argues that adaptability to technological advances is a factor of training. This could be because most teachers and students had ICT skills which were too low to implement computer use in teaching and learning as expected.

Strategies to increase ICT literacy among teachers in secondary schools are highly important as a means to diffuse ICT skills in schools. Accordingly, the design of staff development and immediate ICT technical educational support could be key considerations. Teachers need to be provided with chances to observe the ICT integration by their associates in the classroom. This would allow them to learn about it and judge its potential benefits. The importance of making observations indicates how critical it is for ICT instructional skills to be incorporated in the in-service training programmes. Ideas this can easily be observed and communicated to others and would be adopted more quickly than ideas that are more difficult to see and communicate. The conclusion drawn from this is that the level of ICT trainings among teachers and learners were an influence on use of ICT in teaching science subjects.

Teachers need to master ICT skills that will enable them to use technology effectively in teaching. It has been increasingly acknowledged that, a key factor in successful the implementation of ICT in teaching is teachers' professional development (Downes et al., 2001: Farenga et al, 2001: Fiszer, 2004: Fullan et al., 1999: Guskey, 2000: Mathew et al., 2002: Strudler et al, 1999). Traditionally, education researchers and planners have believed that professionally trained teachers are more efficient and effective than untrained ones (Ogwel, 2008). The training of teachers and learners was a key factor in implementation of ICT in teaching and learning science subjects as revealed in this research. Training was important, as it provided not only knowledge, but also the handson skills that enable the ICT users to apply it for teaching and learning science subjects. Training was also vital because 80.5% of participating teachers and learners had never used a computer before the introduction of the projects in their schools. The level of training in ICT skills was therefore useful in assessing use of ICT in teaching science subjects in NEPAD and Cyber schools in Kenya.

This investigation demonstrated that teachers were not able to utilize new methods for teaching in both NEPAD and Cyber e-Schools, because many of them were not trained or familiar with the new ICT methods. There was hardly enough computers and time for Internet access to enable them utilize the new methods they had acquired in using ICT in learning and teaching. It is evident from the study that most of both NEPAD and Cyber e-Schools teachers could not use ICT skills in teaching effectively. This is because they were not sufficiently trained and there was no enough time for them to utilize whatever ICT skills they had acquired through their own training efforts.

On the other hand, technical training in ICT among teachers was not satisfactorily carried out. The association between teacher's technical competence and use of ICT in teaching and learning was found to be significant at p =0.000, which was below the study's level of significance (0.05) or 95% confidence level. There is always a need for technical support and maintenance as soon as computers arrive into schools (Granger et al., 2002: Hakkarainen et al., 2001). In addition, according to Hepp et al (2004), unreliable ICT facilities in schools have been reported to be "the best innovation killer". Other studies have reported a significant positive correlation between the technical assistance received by schools and progress in implementing ICT in teaching (Byrom, 2001).

The conclusion drawn from this is that if teachers acquire ICT technical skills, they will be able to use ICT facilities more effectively in teaching and learning science subjects since they will be able to fix minor ICT technical ICT problems rather than wait for external support. Lack of technical competence therefore impedes the effective utilization of ICT, since a lot of time will be lost as school seek for technical assistance which may not be forthcoming thus influencing use of ICT in teaching and learning.

There is a need for effective ICT technical training because most of the NEPAD and Cyber e-Schools computers were refurbished and often non-functional and thus, required constant maintenance. Furthermore, the lack of effective technical training among teachers was therefore a serious omission in the NEPAD and Cyber e-Schools programme in Kenya.

It is worth noting from this survey that many teachers embarked on efforts to equip themselves with ICT skills. The enthusiasm of the teachers in taking private ICT courses boded well with ICT utilization in teaching and learning science subjects in the schools. The lack of effective ICT skills, evidenced by the present study, suggests that teachers and learners will need to familiarize themselves with the technology, as observed by Goldman *et al.* (1999), before settling down to effectively integrate technology with content effectively. This means that the period of integrating ICT into science curriculum will take longer than probably previously expected.

Schools may also have to resort to the following suggested solutions (Lundall and Howell 2000), to keep their ICT programmes functioning:- outsourcing some of the work regarding computer networks; sharing ICT technical staff with other schools in the neighbourhood and combining certain roles such as ICT technical support staff and teaching science subjects. The recommended solutions are critical in situations such as the NEPAD and Cyber e-Schools programmes, where schools used refurbished computers that were prone to breaking down quite often.

Twenty two per cent of NEPAD and Cyber e-Schools learners did not receive any training in all ICT skills at all and 21.3% of the learners were not well trained. Learners spent less time being trained than their teachers. 29.0% of learners were trained for less than two days while 5.6% teachers were trained two days. No training regarding ICT information skills was provided among learners even though some teachers had been exposed to such training.

A number of researchers emphasize that training in ICT skills development for learners prerequisite for the utilization of computers in teaching and learning (viz. Addo, 1999, 2001: Holland, 1999: Clyde, 1997: Hawkridge et al, 1990: Nahl and Harada, 1996: and Kafai and Bates, 1997). Clyde (1997) also notes that using computers for educational purposes requires knowledge and skills that are related to the hardware computer system, the software and the information resources. The findings of this investigation reveal that not enough ICT skills hence confidence in using ICT in learning were developed among the learners. This is because only 14.9% of learners had always access to a computer for practice after training sessions. Furthermore, only 32.1% of learners did not have access to computers to practice on after ICT skills training.

It could be argued that learners in NEPAD and Cyber e-Schools would have received continuous training in ICT skills as the programme progressed. The importance of mastering ICT skills, stressed by Nahl and Harada (1996) and Kafai and Bates (1997), cannot be over-emphasized. It must also be noted that, learners who were not ICT skilled could be intimidated during the use of computers for learning in the NEPAD and Cyber e-Schools programmes, as was observed by Holland (1999). Learners would have performed better in science subjects had they been trained adequately. For instance, Nahl and Harada (1996) found that students who reported that they were more experienced in the use of computers performed significantly better in computer-aided learning than those with less experience. Kafai and Bates (1997) concluded that, students who had more experience on use of the Internet dominated computer interaction processes in learning. However, those with more computer experience became the teachers of search teams in computer-aided classes. Nahl and Harada (1996) advise that self-confidence in ICT use in learning can only be attained through practice with computers and training in ICT skills.

The majority of learners were unable to use computers effectively because they had not attained the required computer and information retrieval competencies. In Kenya and other developing countries, the quality of in-service training in use of ICT for learning and teaching is crucial and more important than the nature of the hardware and software provided. The primary factor that has an influence on the effectiveness of learning is the pedagogical design that justifies the how, why and the way in which ICT is to be used (Wang and Woo, 2007). Jimoyannis and Komis (2007) agree that teachers are more likely to make use of ICTs in their teaching and learning practices if they are convinced of ICT effectiveness and usefulness. Means (1994) noted that there is tremendous need for teacher training in areas that demonstrate to teachers the potential of various educational technologies in learning and teaching.

The acquisition of ICT skills alone by teachers without the appropriate pedagogy is inadequate for effective utilization of ICT in teaching and learning (Hakkarainen et al, 2001). According to Sabieh (2001), although it may be relatively simple to teach technological skills, this is not the case when it comes to learning how to use technology as a pedagogical tool. Indeed, teachers need ICT skills, but they also need knowledge and skills that enable them to use ICT in pedagogy. More often than not, ICT skills professional development focuses on teaching ICT skills without showing teachers how to integrate these skills into their specific subject areas (Mathew et al., 2002: Sabieh, 2001). However, it is necessary to teach teachers how to incorporate what they learn in their teaching strategies and science activities (Sabieh, 2001). Consequently, Somekh and Davis (1997) warned of much time spent on specific ICT skills, which are not transferable to the classroom setting. Teacher training in form of isolated skills on hardware and software can have limited impact on teacher practice. According to Granger et al. (2002) and Brand (1997), isolated ICT skills acquired during workshops and courses do not guarantee their use by teachers when they return to their science classrooms. Thus, attention should be given to the transferability of the acquired ICT skills into the science classrooms.

The impact of new knowledge and ICT skills acquired by teachers during their professional learning remains limited if teachers cannot implement them in their instruction. Graham and Thornley (2000) pointed out the importance of linking both pre- and in-service teacher education with classroom practices. They also suggest that in bridging theory and practice, teacher learning should shift from knowledge reproduction to knowledge use. Similarly, Browne and Ritchie (1991) state that typical ICT succeed if they are integrated at the in-service level, where they could be fitted into the teachers' schedules without disrupting their heavy workload.

5.4.2 Provision of ICT resources to schools

Before using ICT, programmes in teaching and learning science subjects can be implemented. It is vital that secondary schools focus on upgrading their ICT infrastructure (e.g., installing computer laboratories and Internet connectivity) and developing relevant ICT skills of their schools. This study has demonstrated that for a successful ICT utilization in teaching and learning science to take place in schools a strong correlation should exist between ICT facilities and other information resources. Information resources should not be viewed in isolation, but holistically. Moreover, school librarians should be involved in ICT projects and trained in Internet information retrieval skills. This will enable them to guide learners with information retrieval and use library resources to augment their skills and knowledge in science subjects. ICT teachers are also prerequisite to the utilization of ICT in science education but, most importantly, for the integration of ICT into the teaching and learning process. To avoid "dumping" of obsolete computers, a national policy on refurbished computers is required. There also must be standards of the type of computers donated to schools.

As ICT projects cannot take place in schools without the Internet connection, it is recommended that the cost of Internet access, which is predominantly the cost of a telephone line, be fully explored and discussed with role-players during the planning phase of the roll out process. This would avoid accumulated phone bills and the cessation of Internet access. It is also ideal for schools ICT usage projects to utilize Internet-based compact discs (CDs) during the training. Such an approach would not incur Internet costs, but assist in providing the required skills. The current Internet access rate of 20% for schools in Kenya does not bond well with e-school ICT integration projects. Therefore, it must be examined and the same extended to all other African countries.

important, teachers must be able to collaborate and work in teams, across subject categories and, increasingly, across borders. Training in the use of ICT, therefore, has to be part of a much richer science education for teachers and must address issues of pedagogy in the context of global curriculum change (Lundall and Howell, 2000). Though teachers had acquired skills in the use of the Internet resources, they could not utilize the Internet for teaching and learning purposes because the Internet connection was often not available. This investigation established that the Internet facilities provided by NEPAD e-Schools in Kenya was unreliable and did not support ICT training and utilization of ICT in teaching science subjects

Apart from the project team and research-based teaching methods, teachers in NEPAD and Cyber e-Schools were not familiar with or trained in teaching methods that support the utilization of ICT in science education. This meant that teachers were not trained in the required pedagogical skills necessary for ICT integration in NEPAD and Cyber e-Schools e-learning projects. This investigation established that the existing pedagogy in schools did not support computer-based teaching because of the following reasons. The previous professional training of teachers did not recognize modern pedagogies that incorporate use of ICT in learning and teaching science subjects and prevailing in-service training does not integrate ICT into curricula design and training.

The association between various pedagogical skills and use of ICT in teaching science was as follows: collaborative schools projects were found to be significant at P-value = 0.006; students' team learning was significant at p-value 0.015; research-based skills were significant at p-value 0.019, while system-based skills were significant at P-value 0.000. This fell below the study's level of significance (0.05) or 95% confidence level. According to Kiare (2007), most secondary school teachers lack the skills to utilize technology in curriculum implementation hence the traditional 'chalk and duster' approach still dominates in secondary school pedagogy. Moreover, information transfer using ICT is minimal or non-existence in secondary schools. Secondary school teachers also need training on educational technology and the integration of ICT in classroom teaching. According to Carlson and Firpo (2001), teachers need effective tools, techniques, and assistance that can help them develop computer based projects and activities especially designed to raise the level of teaching. The conclusion drawn from this is that access to various training in pedagogical skills positively influences the use of ICT for teaching and learning. This observation concurs with findings reported by Gakuu (2007) who found out that training in pedagogical skills was essential for integration of ICT in teaching and learning in institutions of higher learning in Kenya.

The lack of cognitive resource-based learning environments, including involvement of media teachers in the integration of ICT into the curriculum and the prevalence of use of 'chalk and talk' pedagogy was found in all schools. In addition, the schools sampled for purposes of this study lacked sufficient learning resources such as well equipped computer laboratories and libraries were proportionately few compared to the number of users. Moreover, innovations in education are dependent of teachers' attitudes, beliefs and conceptions (Ogwel, 2008). Teachers are rarely supported in the implementation of reform visions and professional development courses appear to offer generic solutions that do not easily transfer to regular practice. Generally, teachers are expected to design purposeful tasks, provide opportunities for students to develop independent thinking elicit and incorporate students' diverse conceptions in instruction, and validly evaluate learning. Requisite skills for designing tasks that potentially engage students and promote problem-solving abilities are rarely developed in teacher education courses. Moreover, most instructional activities, including practice exercises are derived from textbooks, and inadequate time has been seen to hinder teachers' adaptations of such tasks.

This research further found that the training of learners in ICT skills was unsatisfactory and stood at only 22.2%. About a third of the learners in NEPAD and Cyber e-Schools were not trained at all (29.5%), while close to half of those trained were poorly trained. This could be attributed to the fact that they had spent less time during training than teachers.

No training was provided to learners in database systems, programming and information skills. Training in ICT skills was unsatisfactory because teachers did not have enough time outside their normal duties to teach ICT skills they had acquired during the training period. The learners also had not acquired sufficient ICT skills and confidence in using ICT since only a limited number had access to computers for practice after training sessions. Hence, the learners in the e-schools could not efficiently use the ICT in learning the science curriculum.

This study found that for both NEPAD and Cyber e-schools learners had not fully benefited from the ICT skills acquired by the teachers. This was against the backdrop that 77% of learners were not trained in the use computers as a tool for learning and 89% did not have computers at home. The study also exposed that less time and effort than required was devoted to the training of learners by teachers for both ICT projects. Learners were not skilled in the computer application systems because teachers did not have the time beyond their normal teaching schedules to help them acquire skills in the use of the systems for learning.

In both programmes, the learners' use of Internet resources during science lessons was very limited and not effective. This is because of the lack of training in information skills, the Internet connection was often not being available and teachers had very little time to teach, guide and supervise the learners. This study concurs with the SAIDE Report (1998) which states that unless the issue of availability of ICT resources in schools is addressed, programmes seeking to exploit and implement ICT would have no effect. Furthermore, it would have been ideal for the NEPAD and Cyber e-school ICT projects to utilize the server-based compact discs. The present study argues that the non-involvement of the school ICT teacher frustrated use of the ICT resources because this area is the domain of the school library and ICT teachers.

These findings demonstrate that in NEPAD and Cyber e-Schools, the learners interacted only to a minimal degree with other learners across the globe. Because of this, the learners did not benefit fully from communication skills that are useful in learning science subjects. It was observed that the Internet was often not available in the schools. These findings are also indicative of the fact that learners in the NEPAD and Cyber e-

Schools projects were not able to utilize ICT for collaborative projects. Data provided by this study indicated that, although the majority of them were involved in at least one collaborative project, only 6% were involved in the projects and as few as 3% in three projects, during the pilot phase.

Throughout this investigation, it was apparent that one of the most important objectives of the NEPAD and Cyber e-Schools projects was to integrate ICT into the science curriculum. However, this was not achieved and could take a long time to be realised. Majority of Kenyan teachers and learners in this study believed that, the introduction of computer studies as a subject in the schools would help in improving the speed of ICT integration in the science curriculum. It is assumed that the introduction of computer studies in schools would provide for full-time ICT teachers hence hasten implementation of ICT in teaching and learning. This would provide capacity in terms of time and required personnel that would use ICT in teaching and learning in schools such as the NEPAD and Cyber e-Schools.

The research data has shown that the general ICT school resources and pedagogical situation in both NEPAD and Cyber e-Schools did not provide the requisite environment for learners to effectively think through science projects and the nature of science. The study also observes that the impact of the projects on schools science subjects had been minimal, given the dire resource situation, as well as the teacher capacity and situation in which the projects operated. There was lack of time and ICT skills among the teachers. Learners' ability to think through science school projects and construct their own knowledge was not either introduced or emphasized during science lessons. The non-involvement of school librarians, where they existed, was a setback to the projects. As learners think through their own research projects and use their own acquired information, they often develop their own knowledge and a critical thinking skills process develops. This was not fully developed in both NEPAD and Cyber e-schools ICT projects. This was due to poor ICT information resource situation in the schools and lack of regular Internet access.

There was hardly time for teachers to deliver on the demands of NEPAD and Cyber e-Schools projects, even in cases where they had acquired the necessary skills and confidence. The ICT activities in these schools did not have positive impact on the science teachers' normal teaching duties. This is because teachers were not dedicatedly using the ICT skills on full time basis. They engaged in use of ICT activities only when time was available as the study found.

Many science teachers and learners in NEPAD and Cyber e-Schools had used multimedia computer system. They were very positive that it could assist them in teaching and learning. However, none of the schools had the minimum multimedia requirements to enable the teachers or learners utilize such ICT systems. The science teachers lack time to deliver the demands of NEPAD and Cyber e-Schools projects. One would have thought that the pedagogical support provided by the various ICT resources would raise the morale of science teachers but this was not the case. The teachers felt that the NEPAD and CSTS projects were extra duties for which they were not paid to undertake. According to Lundall and Howell (2000), teachers often do not know what they can do with technology if they are poorly trained. It was noted in this study that teachers had the tendency to use ICT simply to automate traditional teaching methods. The need for support in provision of human resource base to guide teachers is a critical factor. An advisor would be required to facilitate group work among teachers so that there was a sharing of experience and collaboration around the projects. Lundall and Howell (2000) maintain that such practice was prevalent in the developed countries of the United States of America and Britain. They emphasize the need to have Master Trainers, who then serve as ICT resource persons for their colleagues in schools. Lundall and Howell (2000) stresses that, such an expertise could be from other teaching staff, librarians, ICT coordinators, or from volunteers from business people, the parent body or student groups.

The investigation reveals that 37.5% of NEPAD and Cyber e-Schools teachers had used a multimedia computer system before. Of the 37.5% teachers, majority of them (62.0%) have used a combination of text, sound and image while teaching using ICT as a tool for teaching science subjects. Many of the teachers responded positively to the means by which multimedia can assist in use of ICT in teaching and learning. The largest response (72.5%) of teachers believed that multimedia would stimulate the learning process of students. Gates (1994) observes that multimedia stimulates all learning paths by offering information through pictures, written text, sound animation and video. Many of the teachers (67.5%) indicated that multimedia would attract students to practice and acquire skills. The researcher believes this should be a tonic for the NEPAD and Cyber e-Schools programme. The majority of learners (75.3%) have television sets at home and over half (38.3%) view television very often, it is certain that a multimedia system will attract learners to ICT-facilitated learning and teaching. This was reinforced by the fact that (85.1%) of the learners indicated that they prefer sound as an additional medium when using ICT in learning.

The present study has found that no NEPAD or Cyber e-Schools had the minimum requirements necessary for utilizing multimedia in teaching and learning. The majority of teachers (37.5%) however have indicated that with the ICT skills they have acquired they would utilize multimedia for teaching purposes. Teachers who felt they could not utilize multimedia for teaching purposes indicated that they would require further training in technical skills that relate to multimedia.

Several terms are used to refer to the continuing professional development of teachers, such as: staff development, in-service training, professional development, and continuing professional development (Downes et al., 2001: Elmore, 2002). Guskey (2000) defined professional development as; those processes and activities designed to enhance the professional knowledge, skills, and attitudes of teachers so that they might, in turn, improve the learning of students.

Teacher professional development concerned with ICT integration has undergone a significant shift over the last three decades. The first move focused on training teachers to use computers, and was mostly carried out in central locations rather than in classrooms where teachers would use ICT. The second move came after the recognition that ICT integration has less to do with technology itself and much more to do with instructional approaches. Therefore, this move has focused on how to utilise technologies in teaching and learning (Jacobsen, 2001).

It has been noted in this study at several points that well-trained teachers are the main factor that makes a difference between the success and failure of meaningful implementation of ICT and curricular practice (Farenga et al, 2001: Fullan et al., 1991). However, generally, there has been little time spent on professional development in comparison with what has been spent on hardware and software. While principals and administrators can offer a setting for change, teachers are the primary agents of school change (Gillingham et al, 1999). Therefore, extensive efforts should focus on preparing teachers to utilise ICT effectively in their instruction (Jacobsen, 2001).

Both formal and informal learning are to be valued and nurtured in teachers' professional development. Granger et al. (2002) argue that informal teacher education, such as 'just-in-time' learning, Internet surfing, reading, interaction, on-the-job-discussion, and collaboration with peers and/or students is more effective than formal education. Thus, there has been a call to consider such informal learning when evaluating teachers' achievement in ICT professional development programmes (European SchoolNet, 2005). In addition, viewing professional development as special events, which take place at specific time during the year, can restrict teachers' learning. On the contrary, professional learning can occur every day either formally or informally. So, it is increasingly recognised that professional development should be accompanied by the concept of teachers as continuous learners throughout their professional life (Downes et al., 2001: Fiszer, 2004: Guskey, 2000: Mathew et al, 2002: Strudler et al, 1999).

School-based professional development has been widely recognised as the most effective teacher professional learning. Differently from professional development conducted in central locations away from school contexts, a school-based model provides teachers with training in familiar and relevant contexts, clearly with colleagues they know and working with the resources available in schools (Downes et al., 2001: Gilmore, 1995: Tele-Learning, 1999). This model of professional development is also cited as being more receptive to school-based decision-making as well as being able to target specific training needs, such as individual teachers' varying stages of ICT adoption (Sarbib, 2002).

5.2.5 The Role of ICT Infrastructure Providers in ICT usage in Teaching and Learning Science in NEPAD and Cyber E-Schools

The NEPAD and Cyber e-Schools had less than the minimum requirements of the pre-requisite information resources. The schools lacked adequate computers, networked laboratories, Internet access, libraries/media centres, media teachers and multimedia centres. The low number of functioning computers and poor Internet access made it impossible for effective collaborative projects to take place. Other technology - television, video machines, radio and overhead projectors – which support technology-based education, existed only in few of the schools. Though information resources situation in many schools was gradually improving, they were not adequate to support use of ICT in teaching and learning science subjects and therefore needed massive improvement.

Refurbished computers appeared to be the most feasible option for providing disadvantaged schools that had poor ICT infrastructure. Out of twelve secondary schools that participated in this study, eleven had received their computers as donations from NGOs, the Government of Kenya through the Ministry of Education and NEPAD. Most of the donated computers were old as indicated by 92.5% respondents. Refurbished computers have extremely high level of failure and required constant repairs, maintenance, replacement and updates. This process of maintaining the functionality of ICT infrastructure in schools was frustrating and a barrier to the use of ICT in teaching science curriculum in these schools. The association between roles of ICT infrastructure providers and the use of ICT in teaching and learning was found to be significant at $p = 0.05$, which was below the study's level of significance (0.05) or 95% confidence level. The conclusion drawn from this is that the roles played by both NEPAD and Cyber e-schools greatly influenced use of ICT in teaching and learning science subjects in schools.

The process of obtaining any form of support either from NEPAD, CSTS or the Kenyan government was lengthy, time consuming and services were never availed to the schools at the time when they were most needed. Computers and other ICT infrastructure facilities that were still under warranty had to go through lengthy bureaucratic channels before repair could be carried out. Thus, the lack of effective support by the concerned ICT infrastructure providers negatively affected efficient use of ICT in teaching and learning science subjects in the selected schools. The association between support received by NEPAD and Cyber e-Schools in regard to the use of ICT in teaching and learning was found to be significant at p =0.05 and was below the study's level of significance (P-0.406 more than 0.05. The conclusion drawn from this is that although it was important to support the ICT projects in school, this did not seem to affect the use of ICT since it was none existent.

The major challenges attributable to the ICT infrastructure providers included; low number of functioning computers in NEPAD and Cyber e-schools that was considered a serious limitation to the projects, lack of Internet access, resulted in inability to engage in collaborative learning projects and inability to integrate ICT in teaching and learning system, meant that the projects have not achieved a major outcome and lack of funding seriously interfered with the success and sustainability of the projects. The projects were expensive ventures since cost of maintaining the ICT systems were out of reach for most secondary schools in this investigation.

Though cost implications were beyond the scope of this investigation, it impinged on the immediate utilization and sustainability of ICT programmes in the selected schools. Majority of the teachers indicated that the programme was an expensive venture to be undertaken. The science teachers concluded that the cost of maintaining the ICT systems might be out of the reach of their schools for now and in the future. Telephone costs were a major barrier to the implementation of the ICT programmes in the schools. Lundall and Howell (2000) point out that cost, and particularly the cost of Internet access, has been the most important factor for limiting Internet use in schools in Africa. James (2001), emphasizes that the lack of financial sustainability by funding agencies often render medium and long-term projects very fragile and could have limited social impact.

5.2.6 Conclusions

This investigation has established that NEPAD and Cyber e-Schools teachers are not adequately trained on the use of ICT in teaching and learning science subjects, basic technical skills and learner training was not adequate. It was established that the existing pedagogy, as well as existing information resources in NEPAD and Cyber e-Schools schools, does not support use of ICT in teaching science subjects effectively. The investigation also found that where teachers have received some training, there was not enough time to implement the skills gained by teachers in the NEPAD and Cyber e-Schools programme because of lack of time. However, it was reported that schools that had integrated ICT in teaching science subjects especially cyber schools students' performance in academic work was noted.

Learners experienced some problems accessing digital science content in NEPAD and Cyber e-Schools due to lack of good computer network and limited skills. Poor access to science information from Internet was noted to be the student's lack of the skills to do so, poor Internet connectivity and lack of Internet. While multimedia could be used effectively to enhance use of ICT science education, most schools did not have the required equipment to use it. Although the cost of computer systems was not a feature of this study, it was observed to be a major factor in utilizing ICT in the NEPAD and Cyber e-Schools programmes. The ICT projects in schools cannot be sustained if the cost factor is not given attention and resolved. The study has recognized that the efforts of infusing more ICT in teaching and learning science subjects are constantly thwarted by a number of key challenges. They include the following:

i. There is inadequate technological infrastructure to support the integration of ICT into the school curricula. This refers to issues as poor or lack of national ICT policy, low Internet connectivity, inadequate supply of electricity and inadequate number of PCs.

There is need for policies that deregulate satellite communication and other telecommunication links, regulate ISP, regulate government and cross-border data flows. ICT policies can help address stringent tax regimes. Internet access is now widely available in the country but only few schools have it and where available, the efficiency is poor as many schools experience downtime, several times a week. The telecommunication services are the root cause of these downtimes in terms of, either, low bandwidth, technical faults and other network configuration problems. There were also many external systemic factors such as electricity, transport networks, and import duties, which also impact negatively on Internet service delivery on the African continent. In some of the selected secondary schools, access is limited, not only by the number of Internet service points, but also by the time that access is available or permitted, leave alone the difficulty of bandwidth. Yet for teaching and learning purposes, access to the Internet is no longer a luxury or privilege for only a few people because in academic circles, access to the Internet and hence to the world's stores of knowledge is a necessity. NEPAD and Cyber e-schools still need to lobby to gain greater access to Internet resources for academic staff, students and/or research. Consequently, there is an urgent to improved ICT policies and infrastructure in secondary schools.

ii. Sustainability of ICT is the major non-technical constraint in both NEPAD and Cyber e-school. The unprecedented and multifaceted growth and development of the ICT themselves poses another challenge. The rapid pace and transient nature of technological development requires sustained funding. Funding has been found to be biggest hindrance to the development and integration of ICT in the teaching and learning science subjects in e-Schools.

iii. Among the constraints cited by the respondents in the study were the issues of: re-training teaching staff so as to improve their ICT competency; lack of systems manager/support staff and/or ICT experts; and low levels of students' epistemological access (Minishi-Majanja, 2004). Manda (2006) also observed that lack of ICT knowledge and skills among staff and learners is a major obstacle to use of ICT in learning and teaching.

There is still a serious need for ICT technical support staff with high-level expertise in the maintenance of all aspects of ICT infrastructure in the schools. Because of poor maintenance and insufficient skills to diagnose system problems, there are many faulty computers in the schools, which could easily be re-activated and used. The problem of technical expertise was two faceted. In the first place, there were no enough people qualifying or attaining ICT specialist skills at the speed at which the technologies were being adopted. Secondly, the problem of brain drain whereby the few ICT experts opt for better paying jobs instead of being employment in schools.

The study further concludes that, both NEPAD and Cyber e-Schools use of ICT in teaching science subjects has achieved limited impact on ICT use in teaching and learning e-science subjects in schools. This is because the Internet was not available in most of the schools. There was minimal support from both school administration and project managers. Nevertheless, modern insights into science education have been gained and new approaches to science education developed in the schools, as well as new challenges. Teachers have been provided with additional skills, including the ability to utilize many computer application programmes.

International collaboration with peer learners, for example, was developed in the few schools that had Internet access and engaged in collaborative projects. Access to the NEPAD and Cyber e-School maze of information was available at schools that had Internet access. Teachers and learners utilized a few new methods for teaching and learning science subjects at least. NEPAD and Cyber schools drastically differ in the size and direction of relationships of students' and teachers overall ICT use for teaching and learning science subjects, gender, teaching experience. These results mean that ICT is not commonly used in teaching and learning science subjects, i.e. the instructional methods used seem still far away from employing use of ICT in teaching science curriculum as demonstrated in hypotheses.

A further key conclusion is that the necessary resources and capabilities required for use of ICT in teaching and learning science subjects in secondary schools should include effective well trained teachers and learners in ICT usage of digital science materials (content). It also needs to include availability of ICT infrastructure for example well equipped computer laboratories, networked computers, reliable power supply, affordable Internet connectivity and security. ICT maintenance and technical support is also necessary. Furthermore, adequate time allocation per student on the computer at sufficiently low costs is important to enable the students to become proficient ICT users. This study found that the effective use of ICT in teaching and learning science subjects in the sampled secondary schools was hindered by the all the previously mentioned above factors.

As has been highlighted, the school environment is significantly related to the use of ICT in teaching science subjects in NEPAD and Cyber e-schools. Consequently, the location of the schools, access to Internet, availability of electricity supply and the physical environment within computer laboratories plays a major role in the effective utilization of ICT in teaching and learning science subjects.

Schools which have a significant number of functioning computers may enhance their utilization in teaching and learning science subjects, since the computer sharing ratio will be enhanced. Furthermore, network connection and availability of file servers positively influences the use of ICT in teaching and learning. Consequently, for purposes of efficiency and effectiveness in using ICT in teaching science curriculum in schools, computers need to be made available for both teachers and students at the most preferable ratio of 1:1. This is assumed to increase learner's concentration and capacity to absorb all learning materials.

The component of training in ICT related skills for both teachers and learners is crucial for the effective utilization of ICT in teaching and learning. Conversely, a lack of it will impede the effective use of ICT. Also, the duration of the training should be increased to enable teachers and learners to have enough time to practice the new acquired skills and perfect their masterly of the computer programmes. Apart from ICT skills, technical skills were found to be an important factor in the integration of ICT in teaching science subjects since teachers who could not fix minor computer technical problems would prefer to use the 'talk and chalk' teaching method. This would lead to a lot of time wasting especially when computers break down and the teachers have to wait for external technical support. Lastly, access to various training in pedagogical skills was found to influence use of ICT for teaching and learning in science subjects.

When the available ICT resources are effectively used, the impact will be felt more in well ICT resourced schools as compared to resource-deprived schools. This calls for institutions to increase the number of ICT resources in their schools, rather than wait for ICT facilities from external sources in the form of donations. The providers should therefore consider giving more technical supports to institutions because this will enhance usage of ICT in teaching and learning.

5.3 Limitations of the Study

The present investigation was undertaken in an environment where issues such as ICT, the knowledge economy, digital divide and their implications on education and development in developing countries are not well known and understood. In such a context, there was limited access to information from the respondents during the study. Consequently, the sample size needed to be restricted as well as the response rates. If adequate funds and time had been available, a larger sample would have been preferred. Normally, larger samples give better results and hence are more reliable. However, given the homogeneity of the population from which the sample was drawn, the sample size limitation was compensated for by the inclusion of a comprehensive Literature Review that helped conceptualize this study.

5.4 Recommendations

It has become apparent throughout this study that lessons have been learnt and useful insights gained to guide present and future roll out plan in use of ICT in teaching and learning projects and processes.

5.4.1 Training in basic ICT skills

Teachers are the key change agents behind the adoption and use of ICT in teaching and learning science subjects. In order to enlist staff support and involvement, it is useful to integrate informal use of ICT support into the formal teacher-training system so that less experienced teacher trainers obtain timely assistance. In addition, multiple incentives needed to be provided such as workload reduction, recognition and reward in departmental evaluations, increased research allocations to encourage the use of ICT in teaching and compensation for those providing educational or technological assistance to teachers.

A national technical ICT strategy for teachers should be developed. Training of the teachers should probably proceed to an online technical training format instead of the limited level of face to- face-training teachers had acquired. It is argued that the limited technical training provided during the NEPAD and Cyber e-Schools project did not provide the teachers with the knowledge and skills to be able to provide the learners with the right information and confidence to solve hardware and network problems. This situation resulted in many of the school computer laboratories being unable to function to their optimum level. It is recommended that the NEPAD and Cyber e-Schools ICT projects should make provision for a highly motivated and dedicated ICT teacher, who should be adequately trained in pedagogical, as well as ICT technical skills. Such ICT teachers should train learners and other teachers in the schools in the use of ICT in teaching and learning science subjects.

This study recommends that teachers be supported with face to face-to face training in the use of particular ICT skills until they are familiar with it, master its use, develop the required confidence and use the skills on their own. Taking into account how teachers received their training in the past. It will be difficult to embark on an online training course to master application or technical skills if the rudiments have not been achieved.

Teachers viewed school ICT projects in this study as additional, unremunerated duties. It is therefore important to involve district education officials, school principals, heads of departments and participating teachers in project design and implementation. With such a holistic and inclusive approach, schools will be more receptive to ICT use and development, because the education managers will have endorsed the projects. Ntutule and Perold (2001) found that principals who were originally cautious of ICT projects became more co-operative once they knew regional and district managers were involved. With the involvement of school managers and administrators in the planning and implementation of school ICT projects teachers will be able to see the urgency and adjust their time to accommodate the projects. Closely related to this is the recommendation that use of ICT in schools should be integrated with the school administration. This means that the principals, science laboratory and assistants, administration clerks in the schools should be well trained in utilization of ICT in entire school processes.

It is pertinent that anyone who has aspirations of becoming a science teacher must be provided with a pre-service courses in the use of ICT in teaching science subjects (at universities and teacher training colleges) before they are certified as professional teachers. This approach will enable teachers to be more skilled and confident in ICT skills of teaching in a pre-service training environment. It would also be less expensive to train the teachers in this environment than when they are at in-service programme level.

Where facilities are available, teachers should be given sufficient time and access to these facilities in order to complete their courses and also to become comfortable with using ICT if they are expected to incorporate ICT into their teaching. This investigation noted that many teachers are reluctant to give up their weekends and school holidays in order to attend these ICCT training workshops. Consequently, the courses that are most likely to succeed if they are integrated at the in-service level, where they could be fitted into the teachers' schedules without disrupting their heavy workload.

5.4.2 Provision of ICT resources to schools

Before using ICT, programmes in teaching and learning science subjects can be implemented. It is vital that secondary schools focus on upgrading their ICT infrastructure (e.g., installing computer laboratories and Internet connectivity) and developing relevant ICT skills of their schools. This study has demonstrated that for a successful ICT utilization in teaching and learning science to take place in schools a strong correlation should exist between ICT facilities and other information resources. Information resources should not be viewed in isolation, but holistically. Moreover, school librarians should be involved in ICT projects and trained in Internet information retrieval skills. This will enable them to guide learners with information retrieval and use library resources to augment their skills and knowledge in science subjects. ICT teachers are also prerequisite to the utilization of ICT in science education but, most importantly, for the integration of ICT into the teaching and learning process. To avoid "dumping" of obsolete computers, a national policy on refurbished computers is required. There also must be standards of the type of computers donated to schools.

As ICT projects cannot take place in schools without the Internet connection, it is recommended that the cost of Internet access, which is predominantly the cost of a telephone line, be fully explored and discussed with role-players during the planning phase of the roll out process. This would avoid accumulated phone bills and the cessation of Internet access. It is also ideal for schools ICT usage projects to utilize Internet-based compact discs (CDs) during the training. Such an approach would not incur Internet costs, but assist in providing the required skills. The current Internet access rate of 20% for schools in Kenya does not bond well with e-school ICT integration projects. Therefore, it must be examined and the same extended to all other African countries.

5.4.3 Government School ICT policy

Teachers, schools and the entire country of Kenya stand to benefit from a national mission of introduction of use of ICT in teaching and learning science subjects in schools. This could be realized through support from the government, along with financial policy support for the use of new technologies and strategic partnerships with ICT industry, the private sector and non-governmental organizations (NGOs).

Policy direction is required to strategically incorporate ICT into teaching and learning. This also could encourage teacher's use of new technologies in their classrooms at national level and especially in the rural areas of Kenya. A national ICT policy framework for use of ICT in teaching and learning should aim at the following:

i. Mobilize human and material resources nationally, with incentives for schools and science teachers;
ii. Address a holistic school information resource situation, to include school libraries, ICT and media teachers and multimedia centres;
iii. Develop human resources among teachers in ICT and management skills;
iv. Explore and deploy appropriate, affordable, but non-specific, ICT skills for schools in Kenya that include satellite technology in wired, wireless or a combination of wireless and wired network environments;
v. Develop infrastructure including telecommunication and electricity supply;
vi. Provide pre-service ICT technical and pedagogical training to all science teachers.

Additionally, teachers and their students need technical assistance to use and maintain the technology. When technology does not function well, a learning opportunity is lost and frustration grows. Timely technical assistance is imperative for secondary schools and students to feel confident that they can use technology in their teaching and learning. With these key enablers in place, the integration of ICT in teaching science subjects is far more likely to be successful.

5.4.4 Integration of ICT into school science curriculum

The integration of ICT into the science curriculum is a complex and long-term process. It involves the availability of full-time, well-trained, experienced motivated science educators. The present work recommends the need to introduce computer studies at all stages of the science curriculum and at all levels. The curriculum should be examinable subject so that learners can derive the full benefits of being educated with computers in schools.

The integration programme must create mechanisms and structures to support teachers and learner collaboration after both have mastered sufficient skills. This should be an effort that should create more time for teachers to plan together, train and collaborate in the integration of ICT across science disciplines (Ntutule and Perold, 2001). Integration of ICT into the science curriculum can only begin if there is less emphasis on the passing of examinations and a reduction of the pressure of teachers' work teaching load .

It is recommended that content usage and the integration of ICT into the science curriculum should begin with the mastering of applications programmes and the application of information literacy. The spirit of enquiry, devoid of a *chalk and talk* approach to science education in African communities, must be inculcated in learners and the learning process. Skills gained from this inquiring approach could be used in specific projects such as collaborative projects with learners in science subjects.

The integration of ICT into science teaching and learning must be conducted in such a manner that science teachers and learners see mastering of application programmes and learning of specific subjects as one complementing the other. As observed during this research, the NEPAD and Cyber e-Schools project, learners and teachers regarded themselves as benefiting from computer skills for use in other aspects of life and not for learning purposes only. ICT in the science curriculum should be combined with teachers' administration duties in mind. For instance, using the MS-Excel programme to design school and/or class timetables or mark sheets that are used by teachers in their day-to-day teaching activities. It also fosters the holistic approach to integration of ICT in teaching and learning mentioned earlier.

Care must be taken when recruiting teacher trainers for in-service training, as non-educationists would not be conversant with science teachers' roles and may not relate training to other uses of ICT, thus missing the holistic approach. Accordingly, a mechanism must be in place for monitoring the uses to which science teachers put the skills they had acquired. The tendency to use ICT for other purposes provides grounds and temptation for teachers to leave the classrooms for other services, where their demand might be high. In the present study, only a few science teachers mentioned about their intention to pursue other careers outside teaching, after gaining ICT skills.

The present study recommends that the programme managers educate NEPAD and Cyber e-Schools principals on the role of ICT in science education. This is because motivated teachers who have their roles being appreciated by principals will, in turn, encourage their learners to use ICT in learning. This is critical in the e-schools ICT projects, where this study found use of ICT in teaching as added-on jobs, with no extra remuneration. If these issues are addressed during the project planning stages, such problems are unlikely to arise.

5. 4.5 Educating and Training of Staff

Principals and the school leadership as a whole should be well advised to concentrate their efforts in organizing and facilitating continuous staff development in their schools by organizing workshops, seminars and training sessions for their staff in order to enhance their ability to incorporate ICT in their work and by extension provide a better service for the student. They should also encourage members of staff to obtain additional training especially in the field of use of ICT in teaching and learning science subjects in institutions offering the same training.

i. Institutions need to continue investing in adequate space and functional ICT facilities. Computerization efforts will be frustrated if adequate space, hardware, software and related facilities are not provided to facilitate its utilization by science teachers and students

ii. Internet service providers such as *Orange Kenya, Safaricom* or *Zain* need to improve on the band width available to secondary schools to facilitate faster searching of data by scholars.

iii. The Government of Kenya needs to reduce the taxes charged on imported ICT facilities to make them affordable to institutions. Although the government has already reduced taxation on such imports, currently these charges are still relatively high and hence the cost of such facilities continues to be an inhibiting factor in use of ICT in teaching and learning science subjects.

iv. More computer technicians are required for employment in these schools to maintain the computers. Their work would involve removing all computer viruses, repairing computers in case they broke down, troubleshooting and assisting users and staff to navigate the Internet.

v. All the sampled secondary schools should look for alternative sources of power to help in those times when the main power supply fails. This would involve installation of back-up power supply like generators. There is the need for drastic action to improve power supply in the country.

vi. There needs to be an improvement in the telecommunication infrastructure of the country to facilitate faster access for remote databases in order to satisfy teachers and learners information needs.

vii. The Government should make concerted efforts to provide the required ICT facilities for secondary schools. Budgetary allocations will need to be made available specifically for this purpose.

viii. Government policies must be formulated to take care of issues such as class size, training of teachers on how to integrate ICT in the curriculum for teaching science, funding requirements, provision of ICT facilities in schools by school proprietors (state or private) and the inclusion of ICT-based activities into the curriculum.

ix. Science teachers will be required to allay the fears and apprehensiveness of students to using a computer in learning. The learners should be encouraged to feel comfortable in using computers and guide them to realize the advantage of such use.

x. Teachers also need to be motivated and rewarded for integrating ICT in their teaching methodology. As the survey has shown, in addition to access to infrastructure, content, and having the requisite skills, teachers' motivation is a critical factor in ICT adoption. Policies that encourage teachers to use ICT more effectively will also need to be developed. Policies in this area include measures that raise the confidence levels of teachers (sufficient on-site support, appropriate in-service and initial teacher training in ICT) and also means of recognizing and rewarding the use of ICT (such as appraisal schemes, making good ICT use part of career paths of promotion the or time benefits for teachers engaged in ICT related projects)

xi. Plans for transformation process and management of change need to be implemented with ICT as a primary enabler and amplifier. The key word is transformation. If the organizational and institutional context does not support new working methods, educational practices will not change. Most teachers embrace new technologies in a slow systematic process. Consequently, all changes should be supplemented with adequate management processes which must be linked to a realistic vision. This means allowing schools to experiment within given boundaries on the use of ICT in learning science curriculum.

xii. New competencies and assessment schemes will need to be integrated into the curriculum. This investigation has demonstrated that competence in regard to team work, independent learning and higher order thinking skills can be developed through use of ICT in learning and teaching. Such competencies could be formally included in the curricula and ways of assessing them explored. They are important outcomes of a new and changed science education.

xiii. New forms of continuous professional development in the work environment need to be implemented as part of a culture of lifelong peer learning. In addition, new approaches to teacher training should be related more to the acquisition of life skills, knowledge sharing and peer learning. In order to develop confidence in ICT usage, teachers must be able to upgrade their ICT skills and gain more pedagogical knowledge and this in a much more active way than previously. Moreover, teachers need to become active shapers of their own learning process. This will require a professional environment and culture that allows teachers to do so. An experimental approach using ICT in everyday practice is an important factor in increasing teachers' pedagogical competence. Training programmes should be more school-based and adapted to the particular needs of teachers and fit to personal and subject specific needs, or project related needs. Continuous professional development should be in the foreground enabling teachers to learn how to upgrade their skills. Up-front sessions must be replaced with practice-oriented projects in the practical working environment. Initial teacher training for ICT, not tackled in this review, is an important area for improvement in the future, next to concrete measure for improving in service teacher training.

xiv. The NEPAD e-schools analyzed in this study initially benefited from high ICT investment and a strong political will to foster ICT in education without which impact on teaching and learning cannot be achieved. The evidence showing that ICT influences most e-mature schools and teachers suggests that there is a take-off point in ICT use. Prior to this, little change appears to be happening and investments seem to have little pay-off. Once the change occurs, the benefits accrue. Work should start towards ensuring the majority of schools (80 per cent by 2010 for example) reach the point of e-maturity. A possible way forward is to make use of the existing potential of e-confident users (students, teachers, principals, ICT support) in and around schools (parents, community centres, librarians, museums).

xv. An important issue for ICT consolidation is the focus on content and support services in schools. The value of access to customized interactive digital science content is essential for the successful implementation of ICT in teaching science curriculum. The lack of access to appropriate digital content, related copyright issues and costs of licenses was a major barrier for ICT use in learning and teaching in e-schools selected in this study. Consequently, more actions and solutions are needed at the national level. One recommendation is to join the paper-based and digital content market, harmonizing licensing and accreditation of content. There are ways to reconcile aggregated purchases while maintaining autonomy and independence of individual institutions for example by developing framework agreement based on actual usage. Sufficient ICT support services and maintenance contracts ensuring quality equipment for schools are indispensable conditions to achieve wider impact with ICT in teaching and learning.

xvi. The ICT strategy needs to be integrated into the school's overall strategies. This investigation confirmed that teachers who possess adequate ICT training are most likely to be found in schools where principals have used ICT to support the development of the school's values and goals. If the ICT strategy is integrated into the school's overall strategy, ICT has the greatest potential to act as a catalyst for change and usage (Gakuu and Kidombo, 2009). Furthermore, this overall strategy needs to be developed and evaluated by all school actors and not only by the principal, but in collaboration with the ICT coordinator. This will establish a culture of collaboration and commitment making it more likely that the ICT policy is actually solving a problem that teachers and students are facing in teaching or learning science subjects.

xvii. In order to transform positive attitudes towards ICT into efficient widespread practice e-Schools should capitalize on developing positive attitudes. To achieve greater impact, it is important that teachers support ICT use with a pedagogical approach. This investigation established that there seems to be a mismatch between the potential of ICT for learning and the actual teaching approach for teaching science subjects. The majority of teachers think that ICT can improve learning outcomes, but also think that ICT has little or no impact on their methodology of teaching. This belief can be corrected by hand on practical training, providing easy to use ICT based materials, peer learning and peer sharing of experiences, securing reliable infrastructure, triggering teachers knowledge in their subject, pupil motivation and easy access to research findings.

5. 4.6 Lack of teacher and student access to ICT facilities

A key finding of this investigation is that teachers need to have adequate access to good quality computers, electricity and telephone lines to enable them to access online distance ICT training courses and prepare lessons. Moreover, it is vital that schools have computer laboratories if teachers and students are to be able to access ICT for teaching and learning. There is also no point in spending any time and effort equipping teachers with the necessary skills to integrate ICT into their teaching if schools do not have the computer laboratories and other ICT resources necessary to put those skills into practice with learners.

5. 4.7 Cost issues

Everything, from the development of course materials, the implementation of training programmes, access to ICT for teachers and students, monitoring of the quality and consistency of ICT integration in schools is limited by insufficient funds. This chronic shortage of funds in NEPAD and Cyber e-schools and in Kenyan secondary schools is a perennial problem whose solution is not readily available. This reality presents a fundamental challenge that must be overcome if ICT integration and capacity building is to become a reality in the selected schools and Kenyan science education.

5. 4.8 Improving ICT integration in secondary schools

One of the greatest barriers to ICT development in Kenyan secondary schools is that many of these schools have not yet realized the transformational potential of ICT in what they do. This study observed that, right now, the e-schools just add ICT integration to a long list of nice-to-haves that they cannot afford. Due to other competing spending priorities in schools, ICT integration is regarded as being non -essential and will continue to struggle for attention. However, school administrators could be encouraged to understand the potential that ICT has in transforming science education. The administrators should be convinced of the value of ICT in providing a more efficient and effective learning system in which teachers are taught to be facilitators and enablers for students to gather their own knowledge, rather than being the sole source of knowledge and as such use of ICT could become a catalyst for better performance in science subjects.

To fully integrate ICT capabilities into teaching and learning science subjects, it is important that ICT modules should not be taught separately. Instead, they should become core to the teaching process of every subject. This requires a massive transformation in the way that teacher training in ICT related field is currently undertaken. This is likely to be a long-term process incorporating several consecutive steps that include the development of appropriate training materials, training of teachers, and the provision of both adequate ICT access at training institutions and customized digital science software that is relevant to the curricula taught in Kenyan schools at a highly subsidized rate.

5. 5 Suggestions for further research

Based on the findings of this research it is necessary that systematized interventions are put in place for capacity building amongst teachers in the use of ICT in teaching science subjects in Kenya. This will ensure greater impact of the time, energy and financial resources that are allocated to develop this field. It has become evident in the course of this investigation that further research needs to be carried out in the following related areas:

i. Due to the advancement of technology and the emergence of ICT products that could foster more affordable and sustainable computer access and Internet connectivity, research be conducted into the use of these technologies such as wireless, satellite and open-source software in teaching science curriculum in schools in Kenya particularly rural areas in general.

ii. Replications of this investigation will need to be carried out five or six years from now to establish exactly what changes will have taken place in the use of ICT in teaching and learning science subjects in Kenyan secondary schools.

iii. One of the most formidable challenges to the use of ICT in developing countries highlighted in the Literature review is the challenge of ownership of knowledge and knowledge products, especially in Africa. Accordingly, it is a recommendation of this study that research be carried out to establish the extent to which the African continent is being alienated from the rest of the developed world because of lack of control of the knowledge systems and products that are being used in of the current age of globalization and a knowledge-based economy. A pertinent issue to investigate whether or not African countries (and Kenya in particular) are acting globally or simply developing locally.

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Appendix A: Schools that were participating in NEPAD and CSTS e-schools programmes

CSTS e-Schools	Region	No. of students
1. Agha Khan High School	Nairobi	347
2. Bishop Okoth Girls' Ojolla	Nyanza	294
3. Cardinal Otunga H.S. Mosocho	Nyanza	1050
4. Chepseon Secondary School	Rift Valley	360
5. Chianda High School	Nyanza	747
6. Chumani Secondary School	Coast	442
7. Eshikulu Secondary	Western	601
8. Highway Secondary School	Nairobi	777
9. Kabimoi High School	Rift Valley	523
10 Karuri High School	Central	711
11 Khamis High School	Coast	750
12 Kiriti Secondary School	Central	954
13 Kyangithya Secondary School	Eastern	330
14 Merti Boys Secondary School	Eastern	119
15 Merti Muslim Girls Secondary	Eastern	110
16 Mitaboni Mixed Secondary	Eastern	472
17 Miwani Secondary	Nyanza	306
18 Moi Nyabohanse Secondary School	Nyanza	582
19 Muruguru Secondary School	Central	378
20 Mwea Boys High School	Central	512
21 Nairobi School	Nairobi	1125
22 Nakuru Boys High School	Rift Valley	794
23 Ndakaini Secondary School	Central	388

24	Nduru Boys Secondary School	Nyanza	433
25	Nyamira Girls' High School	Nyanza	513
26	Nyamonye Girls Secondary School	Nyanza	536
27	Ol'Kalou Mixed Secondary School	Central	334
28	Shariani Secondary School	Coast	285
NEPAD e-Schools PROGRAMME			
1	Wajir Girls secondary	North Eastern	422
2	Menengai Mixed secondary School	Rift Valley	92
3	Isiolo Girls Secondary School	Eastern	380
4	Mumbi Girls secondary School	Central	602
5	Chavakali High School	Western	1150
6	Maranda High School	Nyanza	931
Total Number of Students			18350

APPENDIX B- TEACHERS QUESTIONNAIRES

1. What is the name of your school? ____________________
2. What is the name of your province? ____________________
3. What is your school's e-Mail address? ____________________

SECTION A: BACKGROUND INFORMATION

1. Gender?

a) Male teacher [ ] b) Female teacher [ ]

2. What is your highest education attainment?

A	Higher Diploma in Education HDE	[ ]	e	B/Hons.	[ ]
B	Bachelor of Education Bed	[ ]	f	Masters MEd/MA	[ ]
C	Bachelor's degree	[ ]	g	Other (specify)	
D	Honours degree			____	

3. Number of years in the teaching (service)

A	Under 30	[ ]	c	Over 50 years	[ ]
B	31-50 years	[ ]			

SECTION B: SCHOOL ENVIRONMENT

1. Type of area where school is located
   a) Urban [ ]
   b) Semi – urban [ ]
   c) Rural [ ]

2. Indicate how the following physical aspects of classroom environment suit the teaching of science subjects using ICT or digital sciencc content in your school.(tick one level of suitability for each aspect of physical environment)

Aspect	Very good	Good	Fair	Poor	Very poor
Lighting	____	____		____	____
Ventilation	____	____		____	____
Furniture	____	____		____	____
Noise levels	____	____		____	____
Space	____	____		____	____

3. Is your school connected to permanent source of electricity power?
   a) Yes [ ] b) No [ ]

4. If Yes, how reliable is the power source?

a) Very reliable	[ ]	c)	Reliable	[ ]
b) Reliable	[ ]	d)	unreliable	[ ]

5. Does your school have a computer Network?

a) Yes [ ] b) No [ ]

6. If "yes" in Question __, how is it connected to the Internet?(choose one answer)

a Dial up modem (14.4 to 56k) [ ]
b Integrated services digital network (ISDN) [ ]
c Lease line (ADSL) [ ]
g Other. (Specify) ______________________

7. How supportive has your school and principal been? (choose one answer)

a Very supportive – 75% to 100% [ ]
b Supportive – 50% to 75% [ ]
c Luke warm support – 25% to 50% [ ]
d Not Supportive – 0% to 25%
f Other. (specify) ______________________

8. If support has been unsatisfactory what do you think is the main reason responsible for that?

____

____

SECTION C: ACCESS TO ICT INFRASTRUCTURE

1. How many computers do you have in your school?

a Computers in use [______________]
b Computers not in use [______________]

2. How many of the school computers have CD-ROM drives? ________

3. If the school is connected to the Internet, how many computers are connected? (choose one answer)

a One [ ]
b Two [ ]
c Three [ ]
d All
g Other. (Specify) ______________________

4. To what extent are students able to use ICT facilities without assistance? (choose one answer)

a	To a large extent. Many of the students are able to use ICT facilities without help	[ ]
b	To a minimal extent. Only a few students are able to use ICT facilities	[ ]
e	Other. (Specify) ____________________	

5. Where students have problems with use of computer, indicate roughly the percentage range that experience such problems (choose one answer)

a	75% to 90%	[ ]
b	74% to 50%	[ ]
c	49% to 20%	[ ]
d	19% to 5%	
f	Other. (specify) ____________________	

6. To what extent are students able to access information from the Internet without assistance? (choose one answer)

a	To a large extent. Many of the students are able to access information without help	[ ]
b	To a minimal extent. Only a few students can access information without help	[ ]
e	Other. (Specify) ____________________	

7. To what extent are students able to carry out scientific experiments by use of computer (virtual Lab)? (choose one answer)

a	To a large extent. Many of the students are able to read form the Internet	[ ]
b	To a minimal extent. Only a few students can read	[ ]
e	Other. (Specify) ____________________	

8. To what extent are students able to use information from the Internet? (choose one answer)

a	To a large extent. Many of the students are able to [illegible] information from the Internet	[ ]
b	To a minimal extent. Only a few students are able to use such information	[ ]
e	Other. (Specify) ____________________	

9. If students experience problems with use of ICT facility in school and using information from the Internet, what factors in your opinion are responsible for this? (choose one answer)

a	Lack of resources in the school	[ ]
b	Lack of resources at students' home environment	[ ]
c	Lack of experience with the use of The Internet	
d	Laziness	
e	Other. (Specify) ____________________	

10. What is the general student's attitude towards the ICT courses?

a)	Excellent	[ ]	c)	Fair	[ ]
b)	Good	[ ]	d)	Poor	[ ]

11. What is the average performance of students in the ICT courses?

a)	Excellent	[ ]	c)	Fair	[ ]
b)	Good	[ ]	d)	Poor	[ ]

12. Is there significant improvement in performance in other subjects following introduction of ICT-based teaching /learning in your school?

a) Yes [ ] b) No [ ]

SECTION D: TRAINING FOR THE ICT

1. Have you ever used a computer before the introduction of the e-learning programme in your school?

a Yes [ ] b No [ ]

2. Have you been trained for the computer application programme? a) Yes b) No

a Yes [ ] b No [ ]

3. Which of the listed application software have you been trained in? (tick as appropriate)

NO	APPLICATION SOFTWARE	YES	NO
A	Microsoft Word	[ ]	[ ]
B	Microsoft Excel	[ ]	[ ]
C	Power Point	[ ]	[ ]
D	Internet Explorer / World Wide Web / e-Mail	[ ]	[ ]
E	Microsoft Access / Database	[ ]	[ ]
F	Desktop publishing	[ ]	[ ]
G	Web design	[ ]	[ ]
H	Information skills / (Research)	[ ]	[ ]
I	Programming skills	[ ]	[ ]
J	Other: (specify)		

4. Which of the following systems have you been trained in?

No	System	Type/Product/Explanation	Yes	No
A	Hardware	Physical identification of computer components and how these function in the computer system	[ ]	[ ]
B	Operating System Software	Windows 98,	[ ]	[ ]
C		Windows 95	[ ]	[ ]
D		Windows 2000	[ ]	[ ]
E		Windows NT / XP	[ ]	[ ]

F		UNIX	[ ]	[ ]
G	Networking	Networking systems & procedures	[ ]	[ ]
H	None		[ ]	[ ]
I	Other: (specify)	______________________		

5. How many days in total were you trained for the programme?

A	2 days	[ ]	d	More than 10 days	[ ]
B	3 days	[ ]	f	Other (specify)	[ ]
C	4 Days			______________	

6. Have you been trained for the ICT science programme?

a Yes [ ] b No [ ]

7. Which of the listed application software have you been trained in? (tick as appropriate)

No	ICT science programs	Yes	No
a	Physics program	[ ]	[ ]
b	Biology programs	[ ]	[ ]
c	Chemistry program	[ ]	[ ]
d	Mathematics	[ ]	[ ]
e	Others please specify	[ ]	[ ]

8. To what extent did you have a computer to practice after training sessions? (choose one answer)

a	I always had a computer to practice on	[ ]
b	I sometimes had a computer to practice on	[ ]
c	I seldom had a computer to practice on	[ ]
d	I never had a computer to practice on	[ ]
	Other (specify)	

9. How many years have been using computer?

a	Less than 1 year	[ ]	c	2-4 years	[ ]
b	1-2 years	[ ]		More than 4 years	

10. In which subjects do you use ICT as a teaching tool? Check all that apply.

a	Computer	[ ]	f	More than 4 years	[ ]
b	Mathematic	[ ]	g	Art	[ ]
c	Science	[ ]	h	None	[ ]
d	Music	[ ]	i	Other (specify)	
e	Humanities			______________	

11. How many years have you been using computers for teaching science subjects?

a	Less than 2 years	[ ]	c	Over 5 years	[ ]
b	2-5 years	[ ]			

12. Are you able to provide first level technical support for your school computer system?

a Yes [ ] b No [ ]

b) If "no" to Question 6, what is the main reason? ____________________

13. In your school, are you able to use the required ICT tools and facilities that you need in doing your subject schoolwork?

a Yes [ ] b No [ ]

14. Have you been trained for online-collaborative school projects?

a) Yes [ ] b) No [ ]

15. Do you use information from the Internet for teaching purposes?

a Yes [ ] b No [ ]

i) If no why not? (Choose one answer)

a	The Internet is often not available	[ ]
b	There is often no time to surf the Web for information for teaching purposes	[ ]
c	There is not enough skill to find information from the Web	[ ]
	Other (specify)	

16. Which of the teaching methods listed below are you familiar with?

a	Project based	[ ]	f	Research based	[ ]
b	Constructivist	[ ]	g	System based	[ ]
c	Resource Based	[ ]	h	None	[ ]
d	Authentic learning	[ ]	i		
e	Student Team				

17. Which of the methods listed below have been in use before the introduction of the ICT in your school?

a	Project based	[ ]	f	Research based	[ ]
b	Constructivist	[ ]	g	System based	[ ]
c	Resource Based	[ ]	h	None	[ ]
d	Authentic learning	[ ]	i		
e	Student Team				

18. Which of the methods below have you been trained in before?

a	Project based	[ ]	f	Research based	[ ]
b	Constructivist	[ ]	g	System based	[ ]
c	Resource Based	[ ]	h	None	[ ]
d	Authentic learning	[ ]	i		
e	Student Team				

19. In which of the methods named below have you been specifically trained for the ICT project?

a	Project based	[ ]	f	Research based	[ ]
b	Constructivist	[ ]	g	System based	[ ]
c	Resource Based	[ ]	h	None	[ ]
d	Authentic learning	[ ]	i		
e	Student Team				

20. Which of the methods named below have been introduced in your school because of the project?

a	Project based	[ ]	f	Research based	[ ]
b	Constructivist	[ ]	g	System based	[ ]
c	Resource Based	[ ]	h	None	[ ]
d	Authentic learning	[ ]	i		
e	Student Team				

21. Which technology-related skill development have you had access to?

		Yes	No
a	Courses or workshops on basic introduction to hardware/word processing	[ ]	[ ]
b	Courses or workshops on use of scientific software for training secondary schools students.	[ ]	[ ]
c	Courses offered by a private training organization being used	[ ]	[ ]
d	On-site training visits to schools where computers are	[ ]	[ ]
e	One to one professional mentoring	[ ]	[ ]
	department (e.g. a teachers' centre) Courses and workshops offered by an education	[ ]	[ ]
	None	[ ]	[ ]
	Other. (specify)	[ ]	[ ]

22. Which of the training listed above have other teachers on staff had access to?

		Yes	No
a	Courses or workshops on basic introduction to hardware/word processing	[ ]	[ ]
b	Courses or workshops on use of scientific software for training secondary schools students.	[ ]	[ ]
c	Courses offered by a private training organization being used	[ ]	[ ]
d	On-site training visits to schools where computers are	[ ]	[ ]
e	One to one professional mentoring	[ ]	[ ]
	department (e.g. a teachers' centre) Courses and workshops offered by an education	[ ]	[ ]
	None	[ ]	[ ]
	Other. (specify)	[ ]	[ ]

23. How many other teachers have had access to technology related training in your school? ______________________________

24. Are you undergoing any further training to upgrade and equip yourself for technology based education?
   a Yes [ ] b No [ ]

25. If you answered "yes", the course is offered by a (choose one answer)
   a University [ ] b) IT college [ ]
   Others ______________________

26. If you are not undergoing further training, state why not? (choose one answer)
   a Financial constraints [ ]
   b No government funding [ ]
   c No clear government policy on ITCs in education [ ]
   d I don't know which institution to go to [ ]
   e I don't know which institution to go to [ ]
   f Other: (specify) [ ]

27. Which of the following attributes have you acquired to manage your school computer system? (Choose one answer)
   a Ability - Skill to deliver first level support as well as maintenance [ ]
   b Time - enough outside teaching to engage in collaborative projects [ ]
   c Confidence - to operate computers without fear of causing damage to the tool [ ]
   d Other: (specify) [ ]

28. If you have acquired any of the attributes, how do you rate it?
   a Fair - 0% to 50% [ ]
   b Good - -51% to 74% [ ]
   c Excellent – 75% to 100% [ ]

ii- Time:
   a Good - -51% to 74% [ ]
   b Excellent – 75% to 100% [ ]
   c Fair - 0% to 50% [ ]

Iii- Confidence:
   a Good - -51% to 74% [ ]
   b Excellent – 75% to 100% [ ]
   c Fair - 0% to 50% [ ]

SECTION E: ROLE OF ICT IN FRACTURE PROVIDERS/ NEPAD AND CSTS

1. Which of the listed information resources below exist in your school now?

a	Computer Laboratory	[ ]
b	Library/Media Centre	[ ]
c	School Librarian / Media teacher	[ ]
d	School Multimedia Centre	[ ]
e	Internet access	[ ]
g	Network controller	[ ]
h	None	[ ]
i	Other. (Specify) ______________________	

2. Which of the resources listed below existed in your school before the introduction of ICT project in your school?

a	Computer Laboratory	[ ]
b	Library/Media Centre	[ ]
c	School Librarian / Media teacher	[ ]
d	School Multimedia Centre	[ ]
e	Internet access	[ ]
	Network controller	[ ]
	There were no resources present	
f	None	[ ]
g	Other. (Specify) ______________________	

3. Which of the following technology exist in your school for the purpose of teaching?

a	TV(s)	[ ]	i	talking books	[ ]
b	Video Machines	[ ]	j	Sensors	[ ]
c	Radio	[ ]	k	database software	[ ]
d	Data Projectors	[ ]	l	Spreadsheet	[ ]
e	Tape recorder(s)	[ ]	m	floor robots	[ ]
f	video-recorder	[ ]	n	None	[ ]
g	Over head Projectors	[ ]	o	Other. (Specify) ________	
h	Slide/Tape	[ ]			

4. Which of the technology listed below existed before the introduction of e-learning in your school?

a	TV(s)	[ ]	i	talking books	[ ]
b	Video Machines	[ ]	j	Sensors	[ ]
c	Radio	[ ]	k	database software	[ ]
d	Data Projectors	[ ]	l	Spreadsheet	[ ]
e	Tape recorder(s)	[ ]	m	floor robots	[ ]
f	video-recorder	[ ]	n	None	[ ]
g	Over head Projectors	[ ]	o	Other. (Specify) ________	
h	Slide/Tape	[ ]			

5. Does the school have a file server?

a) Yes [ ] b) No [ ]

6. Have you received any support from any of the established and better-resourced schools?

a) Yes [ ] b) No [ ]

7. If "yes" to Question ___, which of the following support have you received?

a	Donation of old Computers	[ ]
b	Donation of new Computers	[ ]
c	Technical	[ ]
d	Mail/Network services	[ ]
e	Other. (Specify) ______________________	

8. If no state why. (choose one answer)

a	We have not asked them for support	[ ]
b	They are not willing to help despite our plea	[ ]
c	Such schools are very far away from us	[ ]
e	Other. (Specify) ______________________	

9. Which of these supports have you received from the project?

a	Emotional	[ ]
b	Technical	[ ]
c	Learning strategies	[ ]
d	Collaborative planning	[ ]
e	Mentor	[ ]
f	None	[ ]
g	Other. (Specify) ______________________	

10. How do you rate the performance of student in national examinations before the introduction of ICT and after introduction of ICT in the following subjects.

	Before introduction of ICT			After introduction of ICT		
	Good	Average	Poor	Has improved	Has remain the same	Has not improved
a) Computer	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
b) Mathematic	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
c) Science	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
d) Humanities	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
e) Art	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
f) Music	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
g) None	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

11. How often do you use ICT tools in the following purposes: (Tick as appropriate)

	Every day	Very often	Twice a week	Once a week	Never
Preparing lessons	[ ]	[ ]	[ ]	[ ]	[ ]
Making presentations / lectures	[ ]	[ ]	[ ]	[ ]	[ ]
Preparing reports	[ ]	[ ]	[ ]	[ ]	[ ]
Processing examinations	[ ]	[ ]	[ ]	[ ]	[ ]
Internet browsing	[ ]	[ ]	[ ]	[ ]	[ ]
Email correspondence	[ ]	[ ]	[ ]	[ ]	[ ]
Teaching your subject	[ ]	[ ]	[ ]	[ ]	[ ]
Personal work	[ ]	[ ]	[ ]	[ ]	[ ]
Administrative work	[ ]	[ ]	[ ]	[ ]	[ ]
Others (specify)	______				

12. Multimedia in the context of this questionnaire, is information (data) in the formats of text, graphics, images (still and moving), and sound combined and generated by a computer.
13. Have you used a combination of any two of the above formats in your training?
    a) Yes [ ] b) No [ ]
14. If you have which of the formats combined have you used? ________________

15. How do you think multimedia as a computer product/tool can help learners in the means listed below to improve upon their knowledge and skills?
    a Attract students to practice and acquire skills [ ]
    b Stimulate their learning process [ ]
    c Make up for inability to read effectively
    d Enhance their concentration
    e Eliminate passive learning
    f Equip students with independent learning habits
    g Build in students curiosity and the quest for knowledge
    h Support their oral cultural background
    i Other. (Specify) ________________________________
16. With the computer skills you have acquired are you able to utilize fully multimedia for educating your learners?
    a) Yes [ ] b) No [ ]
17. If no which area of expertise does you think you need to improve upon?
    a Multimedia Web page design [ ]
    b Multimedia Pedagogy [ ]
    c Technical computer skills [ ]
    e Other. (Specify) ________________________________

SECTION F: BENEFITS AND CHALLENGES OF THE ICT PROGRAMME

1. In what way has the programme been of benefit you?
    a Introduced modern approaches to teaching and learning [ ]
    b Introduced new insights into education [ ]

c Introduced new challenges to my professional development [ ]
d Ushered me into the global educational arena
e Enable me to develop myself as far as the new approach to education is concerned
f Enabled me to equip myself with computer and information skills
g Other. (Specify) ____________

2. In what way(s) has the programme been of benefit to the school?
   a The school has received international recognition (been put on the Internet: Information superhighway) [ ]
   b Modern educational equipment has become part of the schools' teaching and learning environment. [ ]
   c Students are able to engage in collaborative learning with others far and wide [ ]
   d Students acquire skills which they will use at work places or for further education [ ]
   Spill over benefits in the form of infrastructure and logistics have been made available
   e Students performance in science subjects have improved [ ]
   g Other. (Specify) ____________
3. In what way(s) has the ICT been a challenge to the science teachers?
   a More work / responsibility without additional pay [ ]
   b Inability to fully discharge normal teaching duties [ ]
   c Caused conflict with other members of staff [ ]
   d Caused me un-refunded financial expenditure [ ]
   e Caused conflict with school principal [ ]
   g Other. (Specify) ____________
4. In what way(s) has the ICT programme been of a hindrance to the school?
   a Caused conflicts among teachers [ ]
   b Students spend more time at the computer room at the expense of their examination subjects [ ]
   c It is an expensive venture [ ]
   g Other. (Specify) ____________
5. What problems do you anticipate in the future with the introduction of computers to the learning process in your school?
   a Cost of maintenance of the computer system may be out of reach of school (parents) [ ]
   b Traditional culture and language will be lost [ ]
   c Teachers who will not update their skills and knowledge will frustrate the system [ ]
   g Other. (Specify) ____________
6. What suggestions do you have to improve the use of computers for education in your school ____________

____

Thank you for answering this questionnaire

APPENDIX C - STUDENTS' QUESTIONNAIRE

SECTION A: STUDENT BACKGROUND

1. Type of area where school is located

a) Urban [ ]
b) Semi – urban [ ]
c) Rural [ ]

2. Gender

a) Male [ ] b) Female [ ]

3. In what grade are you?

a) Form [ ] c) Form 3 [ ]
b) Form 2 [ ] d) Form 4 [ ]

SECTION B: TRAINING

1. Have you ever used a computer before the ICT was introduced to your school?

a) Yes [ ] b) No [ ]

2. Have you ever been trained to use a computer before the ICT project?

a) Yes [ ] b) No [ ]

3. How have you been trained for the ICT programme in your school? (Choose one answer)

a) I have been trained very well [ ]
b) I have been trained fairly well [ ]
c) Training has been unsatisfactory [ ]
d) I have had no training at all [ ]
e Other(specify) ____________________

4. How many days in total were you trained for the ICT programme? (Choose one answer)

a) 2 days [ ]
b) 3 days [ ]
c) 4 days [ ]
c) More than 5 days [ ]
d) Other. (specify) __________

5. Which of the listed application software have you been trained in?

No	Application software	Yes	No
	Microsoft Word	[ ]	[ ]
	Microsoft Excel	[ ]	[ ]
	Power Point	[ ]	[ ]

Internet Explorer / World Wide Web /e-Mail	[ ]	[ ]
Microsoft Access / Database	[ ]	[ ]
Desktop publishing	[ ]	[ ]
Web design	[ ]	[ ]
Information skills / (Research)	[ ]	[ ]
Programming skills	[ ]	[ ]
Other: (specify)	[ ]	[ ]

6. For which of the following did you find the training to be unsatisfactory?

No	Application software	Yes	No
	Microsoft Word	[ ]	[ ]
	Microsoft Excel	[ ]	[ ]
	Power Point	[ ]	[ ]
	Internet Explorer / World Wide Web / e-Mail	[ ]	[ ]
	Microsoft Access / Database	[ ]	[ ]
	Desktop publishing	[ ]	[ ]
	Web design	[ ]	[ ]
	Information skills / (Research)	[ ]	[ ]
	Programming skills	[ ]	[ ]
	Other: (specify)	[ ]	[ ]

7. Which of the following systems have you been trained in?

No	System	Type/Product/Explanation	Yes	No
	Hardware	Physical identification of computer components and how these function in the computer system	[ ]	[ ]
	Operating System Software	Windows 98,	[ ]	[ ]
		Windows 95	[ ]	[ ]
		Windows 2000	[ ]	[ ]
		Windows NT / XP	[ ]	[ ]
		UNIX	[ ]	[ ]
	Networking	Networking systems & procedures	[ ]	[ ]
	None		[ ]	[ ]
	Other: (specify)			

8. For which of the following did you find the training to be unsatisfactory?

No	System	Type/Product/Explanation		
			[ ]	[ ]
	Hardware	Physical identification of computer components and how these function in the computer system	[ ]	[ ]
	Operating System Software	Windows 98,	[ ]	[ ]
		Windows 95	[ ]	[ ]
		Windows 2000	[ ]	[ ]

	Windows NT / XP	[ ]	[ ]
	UNIX	[ ]	[ ]
Networking	Networking systems & procedures	[ ]	[ ]
None		[ ]	[ ]
Other: (specify)	______________________________		

9. To what extent have you had a computer to practice after training sessions? (Choose one answer)

a) I always had a computer to practice on [ ]
b) I sometimes had a computer to practice on [ ]
c) I seldom had a computer to practice on [ ]
d) I never had a computer to practice on [ ]
e Other (specify) ______________________________

10. To what extent have you been trained for use of computer for learning science subjects? (choose one answer)

a) I have been trained very well [ ]
b) I have been trained fairly well [ ]
c) Training has been unsatisfactory [ ]
d) I have had no training at all [ ]
e Other (specify) ______________________________

11. How often have you used information from computers for class exercises? (choose one answer)

a) Very often [ ]
b) Often [ ]
c) Not often [ ]
c) Not at all [ ]
d) Other. (specify) __________

12. Do you enjoy using computers for your studies?

a) Yes [ ] b) No [ ]

SECTION C: UTILIZATION OF ICT

1. Do you have a television at home?

a) Yes [ ] b) No [ ]

2. How often do you view television (choose one answer)

a) Very often [ ]
b) Often [ ]
c) Not often [ ]
c) Not at all [ ]
d) Other. (specify) __________

3. Which of the following do you prefer in the process of using computers for learning? (choose one answer)

a) Pictures alone [ ] c) Text alone [ ]

b)	Pictures with text	[ ]	d)	Sound alone	
c)	Picture, text and sound	[ ]	e	Other. (specify) ________	

4. Have you used ICT in any of the following ways?

		Yes	No
1	talking books,	[ ]	[ ]
2	spread books,	[ ]	[ ]
3	database software	[ ]	[ ]
4	television with tele-text	[ ]	[ ]
5	video-recording of lectures	[ ]	[ ]
6	power presentation	[ ]	[ ]
8	videoconferencing	[ ]	[ ]

5. How many students share a computer? ____________________

6. In your opinion, what is the approximate percentage of student's access to the computers?

a)	Less than 10%	[ ]	d)	51-75%	[ ]
b)	11-25%	[ ]	e)	76%-100%	[ ]
c)	26-50%				

7. How are you trained using ICT facility at your school?

a) Individually [ ] b) as a group [ ]

8. Is your school connected to permanent source of electricity power?

a) Yes [ ] b) No [ ]

9. If your answer is "yes", how reliable is the source?

a)	Very reliable	[ ]	c)	Reliable	[ ]
b)	unreliable	[ ]	d)	Very reliable	[ ]

10. Please list the problems in the use of ICT for teaching and learning in your school?

____

____

11. Please answer the following questions

		Strongly Agree	Agree	Disagree	Strongly disagree
1	I am afraid to use computer because I do not want to Damage it?	[ ]	[ ]	[ ]	[ ]
2	I would rather avoid work that involves a computer?	[ ]	[ ]	[ ]	[ ]
3	Am not in control when using a computer?	[ ]	[ ]	[ ]	[ ]

4 I would only use a computer when it is absolutely necessary [ ] [ ] [ ] [ ]

12. Please list the advantage of using computer.

____

____

SECTION D: ADVANTAGES AND CHALLENGES

1. In what way do you think the computer as a tool helps you to improve upon your studies? (choose one answer)

a) I am able to concentrate on what I was doing at a time [ ]
b) I enjoy using the computer to learn [ ]
c) I am able to communicate and share knowledge [ ]
d) I am able to access lots of information
e) I am able to develop learning skills
f) I have a lot of fun working with computers
g) Other. (specify) ______________________

2. What is the most important thing you should do to derive the full benefit from learning with computers?

a) Read more about computers to know about what they can do and their limitations [ ]
b) Learn computer programming in order to understand how they function [ ]
c) Practice to learn the correct use of many application programs [ ]
g) Other. (specify) ______________________

3. How do you rate your performance in the following subjects before and after introduction of ICT in your school?

	Before introduction of ICT			After introduction of ICT		
	Good	Average	Poor	Has improved	Has remain the same	Has not improved
a) Computer	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
b) Mathematic	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
c) Science	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
d) Humanities	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
e) Art	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
f) Music	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
g) None	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

4. What suggestions do you have which will help improve ICT in your school.

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Thank you for answering the questions