Information and Communication Technology in A-Level Physics teaching and learning at secondary schools in Manicaland Zimbabwe: Multiple case studies

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by

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Abstract

As personal computers (PCs) and related ICTs become more and more omnipresent than ever before in institutions of education, teachers are faced with the challenge of having to teach in ICT rich environments. Some syllabuses increase this pressure by stipulating where ICT may be applied. While past research efforts have focused on presence of and/or effectiveness of ICTs on achieving various didactic goals, there is limited literature on the extent to which actual practice occurred naturally. It was the aim of this study to determine the extent to which Physics teachers and students used ICT in their usual teaching/learning ambience, referred to as natural settings in this study. Using activity theory as a theoretical lens, multiple case studies were chosen as a strategy using 10 schools, 15 Physics teachers, 20 A-level Physics students and 10 ICT teachers (computer specialists). Questionnaires, observations and informal and focus group interviews were used to elicit responses from students, teachers and computer specialists. It emerged from the case studies that despite the presence of apt ICT infrastructure in the schools and although the teachers had a positive attitude towards the use of ICT for teaching and learning of Physics, teachers were apathetic when it came to the actual use. Some of the reasons militating against use were lack of an ICT policy, school authority, and monopoly of computers enjoyed by computer studies teachers. However among students there were ‘early starters’ who used ICTs outside of school, a situation that tended to change the Physics learning environment. These findings led to a proposal for a post of Computer Specialist (CS) in the schools. The need for developing ICT policy at all levels namely national, Ministry of Education and the school was also proposed. Lastly staff development in the use ICT for Physics teachers was proposed as indispensable.

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May all Glory be to God.

[1] Mathematics-information technology - Science -Technology
[2] South African Association for Research in Mathematics, Science and Technology Education

Glossary and acronyms

A-Level	Advanced level: The last two years of secondary school; Forms 5 and 6.
Bandwidth	The communication capacity of a link between computers: measured in bits per second.
Broadband	A *communication link that may combine microwave, laser beams, satellite, coaxial cable and fibre optics channels*; capable of carrying more than one kind of data at a time and capable of very high speed of bandwidth greater than 200 kbits/second in each direction.
CD	Compact Disc; optical storage media based on laser technology.
Dial-up	Method of accessing the Internet using a modem and a telephone line.
DOL	Division of Labour
HDI	Human Development Index: A ranking of countries from best to worst quality of life. Quality of life is computed based on longevity, knowledge, and standard of living (United Nations Development Programme,)
ICDL	International Computer Driving License
ICT	Information and Communication Technology/ies
IT	Information Technology
LCD	Liquid Crystal Display
MBL	Microcomputer Based Laboratory
Modem	Modulator-demodulator: a communications device that translates computer digital signals to voice-grade signals, for transmission over telephone lines and vice-versa.
PC	Personal Computer
UNESCO	United Nations Educational, Scientific and Cultural Organization
USB	Universal Serial Bus
VSAT	Very Small Aperture Terminal. A satellite based communications technology.

Chapter 1 Introduction

> As we enter the 21st century, educators agree that all teachers will be faced with the challenge of knowing how to use computers … Not only that a teacher must value and be able to use technology but also that he or she feels confident and has the ability to use technology in applying concepts in the classroom.
>
> (Dickson & Irving, 2002:97)

1.1 Introduction

For Physics teachers, Dickson and Irving's (2002) prediction is unfolding into reality as they face the challenge of teaching in a world where Information and Communication Technology (ICT) is ubiquitous. As the delivery of more and more ICT artefacts becomes imminent in schools, a number of questions arise: How ready is the teaching fraternity to take up the challenge of using them? To what extent are the teachers teaching or their students learning with ICT? It is in the field of ICT in Science Education that this study attempts to answer these and other questions enumerated in section 1.3.

This chapter begins with the context of the study, which includes the situational context, a brief overview of previous research and an introduction to the theoretical framework. The research goals and research questions are then presented. Next the research design is outlined identifying the research orientation, the approach, participants, ethical considerations, data collection methods and data analysis procedures. Limitations of the study are pointed out. Lastly an overview of the chapters that make up the thesis is given.

1.2 Context

1.2.1 Situational Context

Until 2002 all A-Level schools in Zimbabwe used the University of Cambridge Local Examinations Syndicate (UCLS) General Certificate of Education (GCE) Advanced level higher school certificate Physics syllabus 9244. One of the aims of the syllabus was to "promote an awareness of the importance of the use of information technology (IT) for communications, as an aid to experiments and as a tool for the interpretation of experimental and theoretical results" (UCLS, 2000: 27). Twenty percent (20%) of the assessment objectives were clearly marked with asterisks (*) where the use of IT was anticipated. Moreover an extract from the booklet, *IT in A–Level Physics*, included in the syllabus document, reads:

> The use of IT is now an important factor in Physics education and it is hoped that all A-level candidates will have the opportunity to experience something of each of the following: Data capture (hardware) ... data analysis (software) … and teaching aids and resources software … (UCLES, 2000: 85).

In the section on data capture hardware, the syllabus suggests use of sensors and data loggers. For analysis software, it suggests that spreadsheet programs exemplified by *MS-Excel* and *Lotus 123* be used to process data captured via keyboard or automatically through data loggers linked to a computer. The spreadsheet facilities cited include: built-in formulae, graphics capabilities, and mathematical modeling for physical phenomena. In the section on teaching aids and resources (software), the booklet states that self-study programs and computer generated images for classroom simulations and demonstrations are available for almost every topic. CD-ROMs are cited as being a potential growth area although admittedly, there were very few relevant for A-level Physics then. The Syllabus went on to say that "in some cases software is available commercially; in others, teachers may be able to develop their own" (UCLES, 2000:87). The latter point seemed rather presumptuous and an overestimate of what was available in Zimbabwe then and what the teachers could actually do especially in terms of software development.

From 2003 only private schools in Zimbabwe (one in Manicaland) continued to use the UCLS Physics syllabus 9244. The rest of the schools switched to the local Zimbabwe School Examinations Council (ZIMSEC) Physics syllabus 9188. This new syllabus adopted all the aims and objectives of its predecessor with the exception of one aim, which made reference to the use of IT (ZIMSEC, 2003).

This omission seems somewhat surprising given the particular drive to use computers by the Zimbabwean Government. The commitment to the use of computers in schools was recently made concrete when between January and March 2005, the President of Zimbabwe went around the country donating state-of-the-art computers at the rate of 10 computers for each of 10 selected schools in each of the ten provinces nationwide. Ten schools in Manicaland province benefited from this initiative.

What is not known is how these computers are being used in these selected schools, and more particularly if they are being used for A-Level Physics despite the silence about the use of ICTs in the newly adopted ZIMSEC syllabus.

1.2.2 Previous Research

According to Huffman, Goldberg and Michlin (2003), computers can be used to create [3]constructivist-learning environments with science teachers' methods significantly improving from the traditional [4]teacher-centered to pupil-centered. Likewise Redish (1993), in his paper, "What can a Physics teacher do with a computer?" identified three types of capabilities of computers relevant for constructivist approaches in physics instruction programs:

- Computers can capture and display data from the real world quickly and accurately. The student can link both the concrete elements of the real world and abstract representation of physics;
- Computers can perform and display complex simulations, making abstract and inferred concepts real for the student; and
- Computers avail modeling tools for students.

He goes on to describe the use of microcomputer–based laboratories (MBL) where the computer can control, capture and display video images and allow students to take data from the screen for example in *pendulum* and *projectile motion.* He further describes examples of best practice of pedagogical use of computers in Physics in projects such as the Workshop Physics and Comprehensive Unified Physics Learning Environment (CUPLE). The computer program includes a collection of tools such as graphers, spreadsheets, lab tools, video tools, data collecting

[3] Constructivist-learning affords students opportunities for learning by discovery and to "build and apply their own knowledge" (William, 2000:188). This is covered in more detail on pages 32-33 in this thesis.
[4] The teacher dominates in the teacher-centred lesson. In pupil-centred methods, students are actively engaged in interacting with the Physics content and processes.

tools and simulators. These are all used to actively engage the student in the Physics learning process.

These approaches towards the use of ICT in the Physics laboratory reveal the need for the teachers, in the first instance, to be aware of how ICT can be used to enhance constructive learning of Physics by their students. The teachers are the ones who formulate lesson objectives drawn from the Physics syllabus and plan the learning outcomes. It is the teacher who decides on the software appropriate for the objectives at hand. The initial focus therefore needs to be on the teachers, their IT skills, their training, and their understanding of integrating ICT into the Physics curriculum and how the use of ICT influences the teaching and learning environment.

There have been a number of studies that have attempted to categorise teachers' varying levels of use of computers. For example, in 1990, Dwyer, Ringstaff and Sandholtz proposed the five-phaseteacher development model as follows: *Entry, Adoption, Adaptation, Appropriation* and *Invention.* Twelve years later UNESCO (2002) put forward a fairly similar four-level conceptual framework to describe the stages of ICT use, which are: *Emerging, Applying, Infusing* and *Transforming*. More recently, Bialobrzeska and Cohen (2005) suggested that there are three levels of integrating ICT into learning, namely through *functional practice, integrative practice* and *transformational practice*. While these are helpful categories for the initial classification of how computers are being used, they tend to focus on the teacher (Dwyer, 1990), the teacher or learner (UNESCO, 2002) or just the learner (Bialobrzeska and Cohen, 2005). What is needed is a more sophisticated way of understanding the complete teaching and learning environment

1.2.3 Theoretical Framework

One way of understanding how ICT influences the teaching and learning environment is to use a theoretical tool such as activity theory. Activity theory is based on the work of Vygotsky and his colleagues Leont'ev and Luria and has been used as a theoretical framework by Lim (2002) to investigate how ICT mediated the learning process of learners in schools in Singapore. In order to fully describe the situation as it applies to the cases under study, activity theory used by Lim (2002) is adapted to the context in Zimbabwe.

The central principle is that ICT does not exist in isolation but is interwoven with the rest of the tools and participants in the learning environment. Lim (2002) identified various interacting activity systems arranged in concentric circles with the central system being the ICT based lesson. Radiating outwards he included the course of study, the school, the education system and society at large in that order. ICT is identified as a mediation tool in the teaching and learning activity system.

This study also draws on the work of Yamagata-Lynch (2003) who used activity theory as an "analytic lens" to understand the role of a professional development program for integrating technology into schools.

To make the research project manageable the study was confined to ICT tools mediating in the course A-level Physics, the school as the case, physics teachers as key players in the community group and the course Physics as the curricular focus from which the teaching and learning objectives are drawn. The idea in mediation as conceptualised by Vygotsky, (1978) refers to the students learning with a variety of tools at their exposure.

1.3 Goals and Research questions

The intention in this research was to study the extent to which Information and Communication Technology (ICT) was used in selected schools in the Manicaland region in Zimbabwe in the teaching of Advanced-Level (A-Level) Physics.

The specific subsidiary questions addressed to meet this goal included:

- Which of the teachers are using ICT in A-Level Physics?
- How do the A-Level physics teachers view the exclusion of any reference to use of IT in the ZIMSEC syllabus 9188 in comparison to the former UCLES syllabus 9244?
- To what extent are the teachers using ICT in A-Level Physics?
- To what do teachers ascribe their capacity and interest in using ICT in A-Level Physics?
- How is the teaching and learning environment changing as the result of teachers using ICT in A-Level Physics?

1.4 Research Design

1.4.1 Research Orientation

This study takes a critical realist (Sayer, 2000) perspective. Within this paradigm the thrust is to understand and document what is going on in the chosen sites. Thus the teachers were allowed opportunity to tell their own stories of how they were able or unable to use ICT in the teaching of A-Level Physics. The idea was to get a snapshot of the reality of the ICT infrastructure as it prevailed at each site and relate it to the way teachers and students used it, mediating the teaching and learning of Physics.

1.4.2 Approach

In order to cater for the many facets of activity system of ICT mediated teaching and learning, a case study approach was chosen. In general "case studies strive to portray what it is like to be in a particular situation, to catch the close up reality ... of participants' lived experiences, of thoughts about and feelings for a situation" (Cohen, Manion & Morrison, 2000:182). Thus the case study option was taken to allow room for exploration of all possible attributes of ICT embedded in the teaching and learning activity system. The research took the form of multiple case studies to increase the chances of identifying examples of best practice.

1.4.3 Research Participants

Physics teachers from 10 schools in the city of Mutare and the periphery within a 100 km radius were involved. This sample included one out of two Group A schools (low density residential area), one Group B school, out of four (high density area), seven mission schools and the only private school in Manicaland. In all, 15 teachers, 20 students and 10 Computer specialists participated in the study.

1.4.4 Data Collection Methods

Three methods were used to collect data, a survey of all 10 schools, informal interviews and observations undertaken during an on-site visit. Data sources included the Physics teacher, the computer specialist and the physics student.

A survey, using a questionnaire with both open ended and closed questions and Likert-scale type statements (Oppenheim, 1992), was conducted at the 10 sites to establish what ICT facilities were available and which of the teachers were using ICT in A-Level Physics. Three questionnaires were developed, each tailor-made for the teacher, computer specialist (CS) and student. The CS was included as Physics teachers are not necessarily IT specialists and they were not expected to articulate exactly what ICT facilities were available at the school.

Semi-structured interviews (Maykut & Morehouse, 1994) were conducted with all 15 teachers to clarify and confirm issues raised, with a view of establishing how the teachers viewed the exclusion of any reference to use of IT in the ZIMSEC syllabus; to what extent they were able to use ICT in A-Level Physics teaching and to what they ascribed their capacity and interest in using ICT in teaching Physics.

From the responses to the questionnaires and interviews, it was intended to visit for further observation one school where a teacher was using ICT in A-Level Physics teaching. The main purpose of the visit was to observe the teaching and learning environment where teachers were using ICT in A-Level Physics to attempt to understand how the use of ICT in teaching Physics changed the teaching and learning environment. However this initial plan was modified when it became apparent from an early data analysis that computers were not being used in any of the Physics laboratories. Instead observations of computer use were made in computer laboratories (labs). Focus group interviews were also conducted at four sites. The focus group participants were the Physics teachers, the students and the Computer specialists who had completed the questionnaires.

1.4.5 Data analysis

The data from the teachers' questionnaires were largely qualitative and therefore inductive analysis techniques were employed. Because of the need to derive meaning during the process, the data were transcribed, coded and categorised according emerging patterns (Taylor & Bogdan, 1998). Since the data from the Computer specialists were largely quantitative they were transcribed to a spreadsheet *MS-Excel* and coded accordingly (Morse & Richards, 2002).

A case outline was used to guide the synthesis and organization of the data from observations and informal interviews. Observation notes were typed into *MS-Word* and incorporated into the case outline framework. Aspects of the informal interviews and the focus group discussions were merged with the field notes data. Field notes were used to construct the case stories (Appendix 6.1).

1.4.6 Validity

In this study triangulation was used as the principal strategy to attend to validity. This was to minimize the level of uncertainty and address issues of reliability and consistency in the data collected (Merriam et al, 2002). The step taken towards validity was an attempt to address the question of how congruent with reality the findings were to be. To this end some redundancy of data collection was employed using multiple data sources. Multiple methods were also employed. Further to reduce the threat to validity due to data gathering instruments, great care was taken in their design including piloting them.

1.4.7 Ethics

In general, research must be designed so that "a respondent does not suffer physical harm, discomfort, embarrassment or loss of privacy" (Cooper & Schindler, 2003:120). In this study non–disclosure and confidentiality agreements were prioritized. Permission was sought from the Provincial Education Director to undertake the research in the chosen schools (Appendix 6.4.1). A letter of introduction was written to school heads and respondents. Informed consent was sought from the respondents. An effort was made to establish and maintain good rapport with the respondents. In the thesis, pseudonyms are used for the schools, the teachers and the learners.

1.5 Limitations

The study limited participants to the physics teacher, physics student and computer specialist in each school. On reflection it became clear that school heads could have contributed significantly especially on policy issues affecting use of ICT in their schools. The fact that some of them spoke spontaneously is a pointer that they are an interested party. Moreover teachers referred to them as one factor contributing to their inability to infuse ICT in their teaching.

Secondly the time spent at a site was rather short. Spending more time with the Physics teachers could have been more revealing as to the reasons for the observed apathetic use of ICT in their teaching.

Thirdly, the rapid changes taking place in ICT development and deployment in the schools were limiting. For example the current General Certificate of Education (International) syllabus 9702 for examinations in 2007 captures a lot on use of the Internet, which was silent in syllabus 9244

1.6 Value of the study (significance)

Computers have found their way into schools mainly through donations, but with little follow up to find out how they have been deployed and for what they are being used. In this respect the study adds to the literature on the use of ICT in the teaching and learning of Science. A study of this nature is long overdue and will hopefully be of benefit to:

Donors: Those who gave computers to schools may be happy to know one way in which computers are being or can be used. The study provides a justification for the need for provision of ICT in schools.

Administrators: The findings hopefully form a knowledge base to support the decision making process of any school administration on use of ICT in teaching and learning and the potential of an enhanced utilisation of available ICT infrastructure.

Physics Teachers: While ICT may not provide a perfect panacea to the problems hindering Physics teaching and learning, the findings provide the Physics teacher with some examples of best practice on what a Physics teacher can do with ICT in the practice of teaching.

Schools: The ICT infrastructure audit in schools was a pointer to strengths of the schools in what is available with potential for use in teaching and learning. The availability on average of at least 20 computers and at least a LAN at a school is a good enough starting point.

Ideal Computer Specialist: The study proposed the post of computer specialist in the school system. This is important for the coordination of all efforts to integrate ICTs in the teaching and learning not only Physics but other school subjects as well.

Further Research: Many issues were raised thus opening avenues for further research.

Researcher: This was an opportunity to sharpen my research skills and learn more about doing research. It is a big stepping-stone into the world of research and an opportunity to share findings within the family of researchers in the field of ICT in Education.

1.7 Thesis Organisation (Outline of Chapters)

This thesis has five chapters: the introduction, review of literature, research design, findings and conclusion. Chapter 2 is a review of literature in which activity theory was described as the theoretical framework for the thesis. Within this framework the Zimbabwean context of ICT use in Education is described. The rationale for the quest to use ICT is given. It also details how ICT has been implemented in teaching and learning of physics in schools globally with some examples of best practice. Chapter 3 is a description of the research design and implementation. Critical realism is briefly introduced as the underpinning philosophy in this study. The case study approach is discussed touching on case selection, participants and data collection methods. Issues of validity of data are addressed. Ethical considerations are provided for. Data analysis methods are also explained. Chapter 4 presents the findings. Data are presented in a variety of ways depending on their nature and source. Tables are used for organizing raw data and charts for more refined data. Care was taken not to over reduce the data so as to keep the essence of each case. Chapter 5 discusses the findings simultaneously attempting to answer the research questions on the premise of the data and literature. It also makes recommendations, which include a proposal for an Ideal Computer Specialist for schools. Finally areas for further research emanating from this study are listed.

Summary

This chapter identified and described a historical curriculum issue on use of IT in implementing the GSCE A-level Physics syllabus of 2000. This was explained as one reason for carrying out this research. A brief literature review was given to support the purpose of the study, the choice of method and to establish a framework for the study. The goal was spelt out together with the research questions. The research design was outlined to include the data collection methods. The potential value of the study was explained and the organisation of the thesis was disclosed.

Chapter 2 Review of Literature

> A socio-cultural approach towards the study of ICT in schools rejects the view that ICT can be studied in isolation, or as a single variable in the learning environment holding all other things constant. Instead it must be studied within the learning environment and the broader context in which it is situated (Lim, 2002:419)

2.1 Introduction

What Cher Ping Lim (2002) envisaged was a holistic approach to the study of the use of ICT in schools and that such a strategy would be based on activity theory. Use of this socio-cultural theoretical framework is gaining momentum in educational research because of its flexibility in allowing for the study of a combination of variables such as *events, activities, contents,* within an activity setting in which ICT is situated (Lim & Hang, 2003).

This chapter briefly describes the activity theory framework to explore the pathways that have been followed in the use of ICT in schools in teaching /learning and explains why it has been adopted for understanding how ICT are used within Physics teaching and learning in schools in Manicaland in Zimbabwe. The layout of the chapter uses as a framework Cole's (1995) garden-as-a-culture metaphor Fig 2.1.

Firstly, activity theory, the activity system and the broader context of the activity system are explained. Secondly, the Zimbabwean context (represented by the outermost circle labeled society at large in Figure 2.1) is described including the communication and electricity grid as issues pertinent to ICT. Thirdly, an elaboration is made of Zimbabwe's education system as a product of two eras; pre- and post independence touching on some policy issues, progression structure, the narrow road to A-Level, the focus on examinations, the secondary school Physics teacher and intervention programs as effort to improve quality of science education.

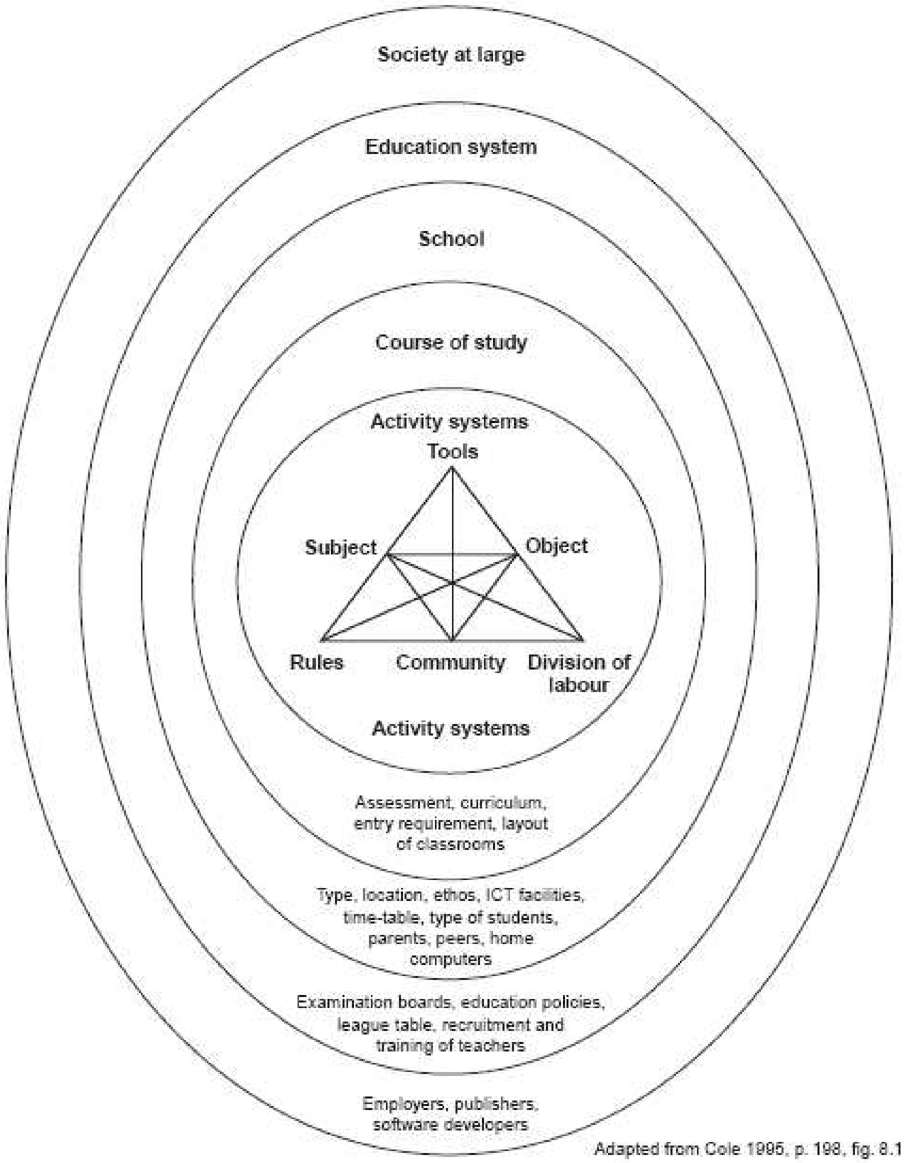


Figure 2.1 ICT within a larger context

Fourth, still using Figure 2.1 as a framework for discussion, the 3rd circle among the activity systems is taken up to look at Zimbabwe's A-level schools; type, location and general infrastructure. Fifth, A-level Physics in the course of study circle is described. The sixth section takes us to the innermost circle, the activity systems tools, defining ICT, use of ICT and other terms. Seventh, the use of ICT in the light of learning theories is documented. Eighth, the question of why use ICT in Physics is addressed. The ninth section looks at implementation of ICT in schools past, present and in future. Tenth, the Zimbabwean story of use of ICT in teaching and learning is briefly portrayed.

2.2.1 Activity Theory

Activity theory is chosen to underpin this study because of its holistic perspective. The essence of activity theory stems from Vygotsky's view of learning where individuals actively construct their understanding of the environment while engaging in goal-oriented activities.

> Learning is no longer studied in the light of students learning in isolation with only their minds to guide them: instead, the emphasis is on students learning with a variety of tools and participants in the learning environment that mediate their goal oriented activities (Lim & Chai, 2003:220 citing Vygotsky 1978; Luria, 1928; Cole, 1995).

Moreover a leading proponent of activity theory, Leont'ev, saw learning as mediated action in which individuals or subjects construct meaning while they interact with artefacts and social others in their environment (McCown, Driscoll & Roop, 1995).

ICT is the newest of artefacts finding its way into the education arena for use in teaching and learning. As ICT finds its way into the classroom, it finds teachers and students traditionally using the chalkboard and textbooks. Science teaching and learning have more sophisticated mediation tools; the so called "science apparatus" housed in purpose-built science laboratories. As ICT enters this arena of existing culture of "material and social resources" (McCown et al., 1995: 42), teachers may have to rethink on their lesson objectives, learn new skills and work with new set of tools and new people such as computer technicians. Students alike may have to learn new skills and to negotiate for new rules. Another dimension is that ICT can be ignored, used with reservation or with enthusiasm, found difficult or easy to use. The question that this study seeks to address is to what extent ICT is being used with reservation or with enthusiasm in the teaching and learning of Science and Physics in particular.

The Vygotskian cultural-historical approach to learning from which activity theory is drawn recognises the use of both material (technical tools – artefacts) and psychological tools – signs (McCown et al., 1995; Yamagata-Lynch, 2003; Lim & Chai, 2003). The focus in this study is on ICT as an artefact, mediating the teaching and learning of Physics. While use of activity theory endeavours to embrace the many aspects in the study of the use of ICT in teaching and learning, the dynamics of the many variables needed a sub-model such as activity system (Lim and Chai 2004:220) to help one fully understand the complexities in the Zimbabwean context.

2.2.2 Activity System

> If we removed human activity from the system of social relationships and social life, it would not exist. … The human individual's activity is a system in the system of social relations (Lim, 2002:414; Lim & Chai, 2004:220, citing Leont'ev, 1981).

Leont'ev's assertion highlights the activity of the individual as an indispensable building block within any social setting (community). In other words the "cells" that made up activity theory are activity systems with the individual as subject in the activity system. The basic model (Figure 2.2) that has been used to visualise the activity is the Vygotsky classical mediation triangle on human cognition (Lim, 2002).

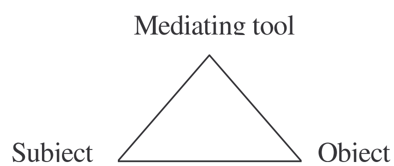


Fig 2.2 Classical mediation triangle

The activity knits together the subject (student), the object (task) and the tool in use. When the students are presented with a task, there are two pathways they can take:

1. Elementary (unmediated) action between the subject and the object represented by the base of the triangle and
2. Higher mediated activity where the subject makes use of a tool or tools to accomplish the object /task at hand (Lim, 2002; Yamagata-Lynch, 2003).

The subject is the individual (in this case the student) or groups of individuals involved in the activity. The mediating tools include artefacts /technical tools (in this case ICTs) and social others.

A full picture that captures the collective and dynamic nature of the activity system is given by expanding the classical mediation triangle by adding the components: community, rules and division of labour (DOL), originally left out by Vygotsky (Engeström, 1987 cited in Lim, 2002; Yamagata-Lynch, 2003). This complete picture is shown in Figure 2.3.

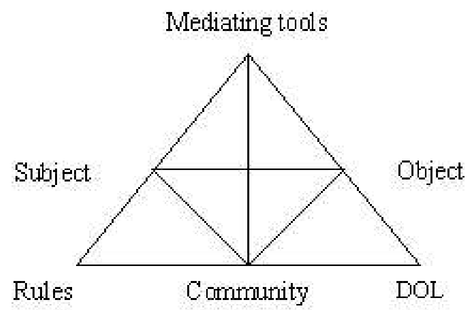


Figure 2.3 Mediation triangle expanded

The following definitions of rules, DOL and community are adapted from Yamagata–Lynch (2003:102), Lim (2002:414):

> *Rules* - refer to the norms, regulations that provide guidance on correct procedures and acceptable interactions among participants. The School *ICT policy* and timetable indicating ICT access are relevant here.
>
> *DOL* - refers to the negotiated distribution of tasks, powers and responsibilities among the community members. Teacher and student *roles* are defined here.
>
> *Community* - refers to the social group that the subject identifies with while participating in the activity in such groups that share the same objective. In this case the Physics teacher, computer specialist, parents, other students, administration staff, ancillary staff, fall into this group.

This study will draw attention to the teacher as well as the computer specialist in the school. McCown et al (1995:43) highlight the teachers' significance explaining that in their interaction, teachers guide children in the appropriate use of tools both as technically and psychologically.

2.2.3 Activity System - The broader context

One limitation of activity theory is its confinement to a micro-culture such as that of a classroom, what Lim (2002) termed a narrow view of culture, only capturing the activities by the students, teachers, ICT, tools and non-ICT tools in the learning environment. The use of ICT in teaching and learning has a larger context, beyond the activity system of the classroom. Metaphorically speaking, in as much as a garden is dependent on the larger ecological system within which it is embedded, ICT mediated classrooms can only be studied comprehensively within the broader context in which they are situated. This study therefore pays attention to "threads" that link the activity system of ICT use in the Physics laboratory to the other activity systems of the school, the education system and some aspects of society at large. The garden metaphor attributed to Cole (1995) and adapted by Lim (2002) given earlier in section 2.0 as Figure 2.1 is adopted to show the schematic overview of the broader context used in this study. This is also used as the framework in the literature review starting in the outermost circle – the Zimbabwean society.

2.3 Zimbabwe society at large

Zimbabwe derives its name from Great Zimbabwe, a stone monument whose architectural features are one of the world's most amazing engineering feats of its time believed to have been built 700 years ago (Chenje, Sola & Paleczny, 1998:17). Geographically Zimbabwe is a beautiful country endowed with scenic mountainous views in Manicaland province (where this study is based), popularly known as the Eastern highlands. These are however barriers to ICT communication channels when it comes to transmission. International tourist attractions include Victoria Falls, the Great Zimbabwe, lake Kariba and extensive wildlife. This combined with a wealth of more than 40 mineral deposits like gold, iron, chrome, silver, platinum, copper, asbestos to mention a few and rich agricultural land, warrants a worthwhile investment into a nationwide ICT infrastructure. Thus in 2005 a nationwide survey was carried out by the National University of Science and Technology to assess Zimbabwe's 'e-readiness' and as a roadmap towards a national ICT policy that is yet to be announced (Zimbabwe. Department of Science and Technology (DST), 2005).

2.3.1 Electricity Grid

While the cities are supplied with grid electricity, the rural areas are marginalized with only five percent of rural homesteads connected to the electricity grid system (Chenje et al*.,* 1998:48). Efforts are underway through the rural electrification program to take electricity to rural areas. Strategic places called 'growth points' and some schools have been supplied with power. In a paper presented at a workshop on *Global network on energy for sustainable development: Workshop on electricity and development* in Nairobi, Mangwengwende, (2005) gave a picture of the access to the national grid electricity (Table 2.1.).

Year	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Urban %	66	66	67	69	70	72	74	78	80	81	82	84	84	85
Rural %	10	11	11	12	12	12	14	16	17	18	20	22	23	25
National %	20	22	22	24	25	27	29	31	34	36	37	39	41	41

Table 2.1 Electrification Access Statistics (Mangwengwende, 2005:4)

In the case of the rural sector, the figures are the percentage of the population that would have access to grid electricity within 10 to 20 km of an electrified rural center. Reconciling this with what Chenje *et al.* cited would mean that in 1998 for example, with five percent homesteads electrified, 16 % of the population had access in rural areas and 78% in urban areas. The electrification position of rural schools relative to other rural institutions is depicted Table 2.2.

Institution	Average installed capacity kVA	Total number completed	%
Business and Government Administration Centres	100-200	901	22
Rural health Centres	50	331	8
Primary Schools	25	944	24
Secondary schools	50	589	15
Small Farms/Irrigation Schemes	25-300	593	15
Village s/other Schemes	10-300	634	16
TOTAL		3992	100

Table 2.2 Electrified Rural Institutions as at 30 June 2005 (Mangwengwende, 2005:4)

Considering the information in Table 2.2, there was an opportunity of moving ICT into only fifteen percent of rural secondary schools in 2005. The question of whether this opportunity was exploited or not, or to what extent it was exploited, still has to be established.

2.3.2 Telecommunications

The provision of public switched telephone networks (PSTN) commonly known, as the *telephone* is paramount to the use of ICT. In Zimbabwe *TelOne,* formerly the Posts and Telecommunications Corporation (PTC), is a parastatal company that enjoys the monopoly of being the sole provider of telephone lines. One implication of this monopoly is a low teledensity (number of lines per 100 people). For Zimbabwe the teledensity was about 2.0 lines per 100 people in 1995 (Figure 2.4). Going by the e-readiness survey report, by 2005 this went up to 2.5 lines per 100 people (Zimbabwe. DST, 2005: 47). However, according to the report, 90% of this telephone infrastructure was in urban and peri-urban locations.

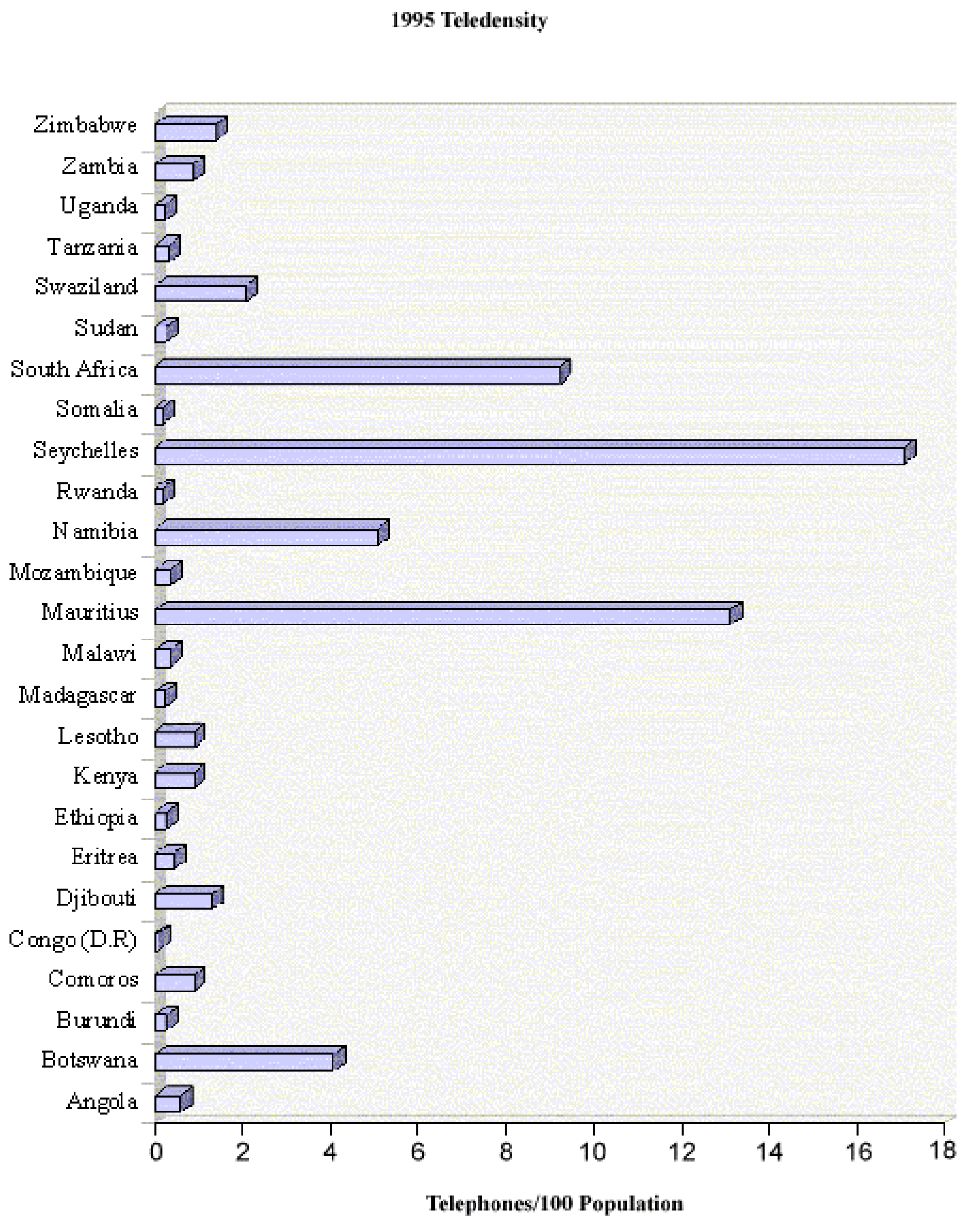


Figure 2.4 Public switched telephone networks (PSTN) provision: Zimbabwe's position Africa region (Mureithi 1997)

Meanwhile new players such as *EcoNET* (Enhanced Communications Network), have come into the market, but currently only as cell phone providers. On the global standard for mobile phones (GSM), "the 9.6 Kbs speed currently available in Zimbabwe is rather slow for data transmission such as on the Internet, but only suitable for voice transmission" (Zimbabwe. DST 2005: 46).

2.3.3 Transmission media

Zimbabwe's international connections, both regional and global, are almost entirely via satellite. In Mazowe, two Standard A earth stations are utilised to access the INTELSAT spacecraft (http://www.uneca.org/aisi/nici/country_profiles/zimbabwe/zimbpol.htm). Currently fibre optics for data transmission only links the two major cities of Harare and Bulawayo. Smaller cities such as Mutare make-do with existing analogue to digital PSTN networks. “In addition newer technologies that use very small aperture terminal (VSAT) and radio links are in use especially for LANs” (Zimbabwe. DST., 2005: 46). VSAT is a satellite based communications technology that is capable of reaching remote and marginalized areas

2.3.4 Bandwidth

The national bandwidth distribution in the major cities and towns is reflected in Figure 2.6. These major cities and towns are the post office protocol (POP) regions whose routes in between the servers carry the bandwidth indicated.

POP REGION	SERVERS	BAND WIDTH
Harare	DNS1, DNS2 Webmail Mail Relay Access Server Terminal Server Radius Server	100 Mbps
Bulaw ayo	Access Server	2 Mbps
Gw eru	Access Server	2 Mbps
Mutare	Access Server Terminal Server	128 Kbps
Masvingo	Access Server Terminal Server	128 Kbps
Kw ekw e	Access Server	128 Kbps
Victoria Fallls	Terminal Server	128 Kbps
Chinhoyi	Terminal Server	128 Kbps
Kariba	Terminal Server	128 Kbps

Table 2.3 National bandwidth capacity (Zimbabwe. DST., 2005:46).

“At present *TelOne* is also the only operator licensed as an Internet Access Provider” (Zimbabwe. DST., 2005: 45), accounting for the full bandwidth given in Table 2.3. The majority of Internet service providers (ISPs), 15 of them in 1998, rely on batches of lines leased to them by *TelOne* which they further sublet, causing bottlenecks associated with ‘middleman’ resale including high cost of Internet access for the end user. (http://www.uneca.org/aisi/nici/country_profiles/zimbabwe/zimbinter.htm). For educational purposes the Zimbabwe Academic and Research Network (ZARNet) was set up by the Government of Zimbabwe as an ISP for educational institutions (Zimbabwe. DST., 2005).

2.3.5 Administrative Provinces

The country is divided into ten administrative provinces; Manicaland, Mashonaland East, Masvingo, Midlands, Mashonaland Centrral, Matebeleland North, Matebeleland South, Mashonaland South, Harare and Bulawayo (http://en.wikipedia.org/wiki/Provinces_of_Zimbabwe). The population is approximately 13 million (http://en.wikipedia.org/wiki/Zimbabwe). Manicaland province had a population of 1.6 million in 2002 (http://en.wikipedia.org/wiki/Manicaland).

2.4 Zimbabwean Education System

> The history of education in Zimbabwe has two distinct phases - the colonial era and the post-independent phase. The situation we are in now is a result of nearly nine decades of politically and socially motivated education policies and two decades of determined effort to right the wrongs of the past ... (Nziramasanga, 1999:288).

2.4.1 Pre-independence

On a time scale the education system in Zimbabwe occupies two periods, pre-independence and post-independence. At independence in 1980, one of the wrongs Zimbabwe inherited from Rhodesia was a socially structured system of education in which two parallel systems existed, African and European education (Zvobgo, 1986; Chenje et al., 1998; Chavhunduka, 2005). The evolution of this education system is chronicled through five commissions and a committee that have inquired into the system to date.

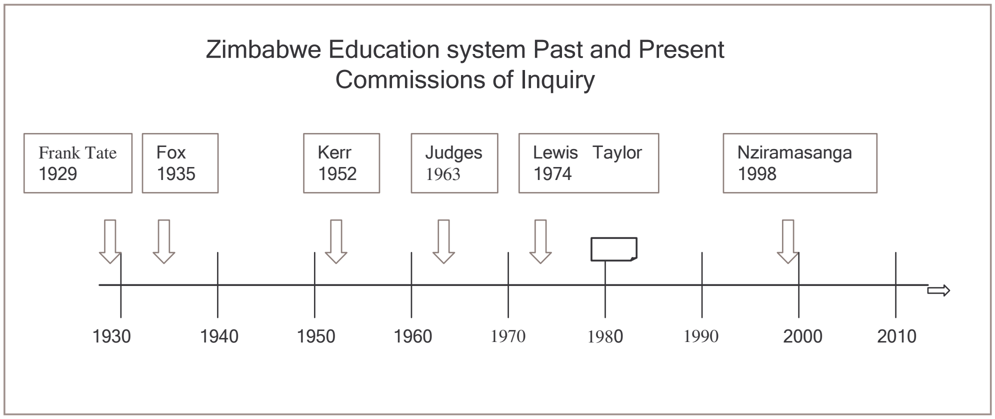


Figure 2.5 [5]**Zimbabwean Education System: the tale of time**

The first two commissions, Frank Tate 1929 and 1935, which recommend a compulsory manual and practical curriculum, and Fox (1935) which recommended a two track education system - academic and practical tracks, inquired into European education only. Despite the restriction of the commissions' remit, some missionaries implemented the same recommendations in African schools (Nziramasanga, 1993:3).

African education, then mainly under missionaries, received attention much later with the appointment of the Kerr Commission 1952 and Judges Committee 1963. One feature highlighted in the African education was the presence of restrictions, better known as bottlenecks, in the progression from primary to secondary school (Nziramasanga, 1999). This gave birth to the policy on automatic promotion for all pupils in primary school. English was to be made the medium of instruction. These policies prevail to date.

The Judges' commission recommendation on vocational education saw the birth of the concept F1 and F2 secondary schools for Africans. These would absorb 12½ % and 37½ % of primary school graduates, a bottleneck that relegated 50% to no secondary education. Thus the F1 track was for the high fliers, the "cream", those who survived the rigors of selection examinations at Grade 7, junior certificate and O-Level to enter A-Level. The high regard for the academic track gave rise to stigmatization of the alternative F2 route, which became associated with inferior capability (Nziramasanga, 1999; Zvobgo, 1986). The fact that the F2 system was unpopular with the majority of the people resulted in it being abolished at independence.

[5] Zimbabwe gained independence in 1980

2.4.2 Post-independence

At independence, the new government simply abolished all forms of discrimination, literally amalgamating the two education systems, removing bottle necks, adopting principal universal primary education and 100% transition to form 1 (Chenje et al*.,* 1998; Nziramasanga, 1999). The demise of the F2 system came and all secondary schools were modeled on the F1 type meaning that every student would be regarded as having potential to study at the A-Level.

2.4.3 The Current Education System

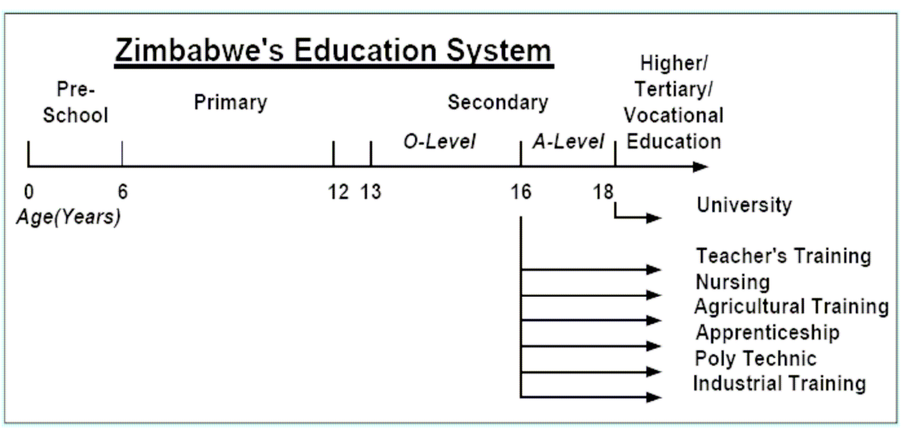


Figure 2.6 Zimbabwe Education system: from pre-school to tertiary education (Unesco, 14/7/2007:10)

The Education System is divided into three categories, basic education (pre and primary), secondary (Zimbabwe Junior Certificate (ZJC), Forms 1-2 and GCE O-Level, Forms 3-4) and A-Level (Form 5-6) leading to tertiary education (Figure 2.6). The race is towards A-Level, at which entry point, the O-Level exam imposes a 'narrow gate', which very few enter: 7 % of O-level graduates (Nziramasanga, 1999).

2.4.4 Examinations

> … However the secondary school system became obsessed with bookish education leading to 'O' and 'A' Level examinations (Nziramasanga, 1999:300).

At independence, the inherited examinations system included national grade 7 multiple choice type questions (as recommended by the Lewis Taylor Committee of 1974); a national examination at ZJC Level set locally; a national exam at O-level and at A-Level set externally by the University of Cambridge. In between these major exams students were subjected to school level mock exams – internal tests along the lines of the external exams. The first local examiners and local syllabus developers were trained by Cambridge University. The result was that, what really changed were the names on the new syllabi, while the contents basically maintained the status quo. A case in point is the A-Level Physics syllabus 9188 whose content is similar to its predecessor syllabus 9244 except for the dropping of the aim on use of IT, the concern of this study. The exam questions maintained the same structure and pattern.

Exam Fever

Of great concern is the fact that the education system has become exam driven (Nziramasanga, 1999) at the expense of any sound pedagogical practice, not to mention quality and relevance. The fact that the pass rate at O-Level is 20% - 25% shows how irrelevant the education is to the majority of students (Nziramasanga, 1999).

Despite this fact parents, students, teachers and everyone have their focus on examinations. There is so much exam fever that school holidays have been turned into extra lesson time (Nziramasanga, 1999), where a great deal of drill and practice for exams is done - of course teachers earn extra and parents pay extra. With the localization of exams, teachers, who are examiners at O and A-Levels, are known by students and parents and therefore attract more holiday lessons clients.

Iteration

Those who fail in any exam sitting go through the process again via the non-formal education route. A proliferation of private colleges has emerged for this purpose (Nziramasanga, 1999). The same drill and practice methods are inflicted on the students. The iteration process helps those who persevere to make the required five O-Levels or two A-Levels for a full certificate.

Exams as object

According to the Nziramasanga Commission (1999), the concern for passing examinations took the center stage to the detriment of all other form of useful learning. Therefore, it would seem that the object, examination (Lim, 2003) in the Zimbabwe education activity system, is a huge determining factor, if not perhaps a barrier, in the extent to which emerging mediation tools such as ICT can be used in teaching /learning Science. The traditional strategies that are known to produce good grades in exams would continue to have a major influence. “The need to get as many A-Level candidates to pass exams and proceed to University places considerable pressure on A-Level teachers" (Chavhunduka, 2005:19).

2.4.5 The Teachers

> No education system can be better than its teachers.
> (Nziramasanga, 1999:448).

The massive expansion at secondary school level after independence resulted in a critical shortage of teachers. For example 52% of teachers in secondary schools were untrained in 1987 or under qualified (Chenje et al., 1998: 54); the situation improving to 11% by 1996. (Note that the primary sources Chenje used were different, the first data set was from the Ministry of Education and the second from UNICEF). During this period A-Level Science was mainly taught by expatriate teachers. Teachers with O-Level teaching experience were also trained further through the B.Ed. program to teach one of Physics, Chemistry or Biology at A-Level. (Chavhunduka, 2005).

2.4.6 Intervention Programmes

While massive expansion after independence was a success story, it had adverse effects on quality of teaching /learning, worsened by the drift towards bookish education. "Both human and material resources were over-stretched" (Nziramasanga, 1999:30; Chavhunduka, 2005).

In Science education in particular there were initiatives to improve the quality of teaching. Projects that have gone through their implementation cycles include the Zimbabwe Science Project (ZimSci), Quest Program, Better Environmental Science Teaching (BEST) and Science Education In-service Teachers Training program (SEITT). The ZimSci Project produced low cost science equipment kits for schools without conventional laboratories. Quality education in science teaching (Quest) was designed for science training courses for science teachers. (Nziramasanga, 1999; Chavhunduka, 2005).

Of particular interest in this study is the SEITT programme that was designed for A-Level science teachers, Physics teachers included, mainly to address low competency in subject content knowledge for some teachers, low competency in appropriate pedagogy for most teachers and insufficient teaching materials in most schools related to budgetary constraints (Chavhunduka, 2005). Pertinent to this study is the networking component where teachers were to communicate via e-mail using the resource center facilities. In the three years under review (1998 –2000), this failed to take off due to poor infrastructure, inaccessibility of computers, limited resource teacher skills in use of computers and the problem of meeting telephone bills.

2.4.7 Secondary Schools in Zimbabwe

The inherited secondary schools in Zimbabwe fell under three groups; A, B and C, by location and responsible authority. Historically Group A Schools were government schools in European residential areas. They were characterized by high quality infrastructure including boarding facilities and well equipped science laboratories. Prior to independence they enjoyed a "comfortable teacher /pupil ratio of 22:1 on average" (Zvobgo, 1986:60). Group B encompassed those state schools, which were meant for Africans located in the African townships (high density). These had no boarding facilities except for two (Fletcher and Goromonzi High), which also went up to A-Level. Group C were the private aided schools such as the mission schools. Mission schools were the pillars and biggest providers of African education in this group. From the outset missionaries strove to do for the African child what the European child was receiving. Some of the best schools in the country still fall into this group. Today private schools in this same group are characterized by high fee structures and can afford to pay teachers over and above the public service salary, therefore attracting high profile teachers. These pre-independence groups had resource allocation implications (Zvobgo, 1986; Nziramasanga, 1999). Table 2.4 shows a breakdown of A-level secondary schools in the Manicaland province as in 2007.

Type of school	Group A	Group B	Group C			Total
	Gvt	Gvt	Mission	Private	Rural Council	
Number in group	2	2	35	1	88	128
Number with A-level Physics	1	1	18	1		21

Table 2.4 A-Level secondary schools in Manicaland offering Physics in 2007

Rural council schools do not offer the subject Physics. Records at the regional office of Education show that most of these schools were only granted A–level status as from 2002, but to offer non-Science subjects. A-Level Physics is offered at the few government, private and mission schools.

2.4.8 Physics: course of study

Physics at A-Level is one science course that can be studied together with two others chosen from Chemistry, Biology, Computing and Mathematics. The current syllabus 9188 for the years 2003-2007 replaced the Cambridge syllabus 9244. Private Schools however continue to offer syllabus 9244 to date. The subject is stereotyped as difficult. High fliers at O-Level enroll for the course, having passed with grade C or better in Physics or Physical Science at O-Level. One requirement is that the subject be done in a Physics laboratory with adequate equipment (usually very expensive –ranging from vernier- calipers, micrometer screw gauges in mechanics to ammeters, voltmeters and cathode ray oscilloscopes in electricity and modern Physics). Pre-requisites for the syllabus include mathematical skills; algebra, geometry and graphs and more recently ability to use ICT as with the Cambridge syllabus.

Those who survive the rigors of the O-Level academic course selection procedures follow the A-Level Physics course. These are seen as strong candidates, normally the 'cream' who must have passed Mathematics well at O-Level and if they take the combination of Mathematics, Physics and Chemistry, and then it is also seen as prestigious.

2.5 ICT as a mediation tool

2.5.1 From IT to ICT

Syllabus 9244 refers to Information Technology (IT) usage in A-Level Physics. *Usage* implies a mediation role. What then is meant by IT and ICT? Put simply IT is the subject; ICT the tools (Smith, 1999). The focus of IT is on the knowledge, skills and understanding of the artefacts - how does it work? How was it designed? Can it be improved on?

ICT has the added dimension of applying the IT knowledge and skills in relevant human activity systems (UNESCO, 2002). ICT artefacts are a product of IT; hence in using ICT there is always the tendency to revert to IT. This becomes a pitfall when ICT is made the *object* - learning about the technology (Plomp, Brummelhuis & Rapmund, 1996) instead of being used in its mediation role. ICT as an *object* courses usually appear in school curricula as Computer Studies, Computer Science, Computing and Informatics.

The focus of this study is the use of ICT as a *medium* for teaching /learning. This sees ICT joining a constellation of other non-ICT mediation tools such as laboratory equipment referred to in section 2.5, through which Physics students can learn and their teachers can teach. For example students could use CD-ROM simulation on Rutherford alpha-particle scattering experiment /or on electron diffraction experiments that are impossible in a Physics lab environment. Students normally would rely on textbook descriptions or what the teacher tells them, now they have an additional "interactive" mediation tool. In another instance a Physics teacher may download a program, *Crocodile Clips* (http://www.crocodile-clips.com/) from the Internet, design a worksheet and distribute such an application on the lab local area network for students to carry out the virtual experiment.

However, all these computer activities assume basic IT skills (or computer literacy), for both the Physics teacher and student .The long-term vision is to see ICT usage in learning situations get to a higher level of ICT as an *aspect* (Plomp, Brummelhuis & Rapmund, 1996). At that level it will be "unthinkable", teaching A-Level Physics without ICT! As an *aspect*, ICT in use vanishes in the background while learning goes on. This is ICT integration in teaching/learning, - an aspiration depicted in many studies that have been carried out on ICT. In view of these uses of ICT as object, medium and aspect within activity systems of schools, to what extent is ICT in use in Physics teaching learning?

2.5.2 The quantity and focus of ICT use

The issue of use of ICT has been very subjective. Twining (2003) lamented confusion about what people meant by *computer use* prevalent in research literature with meanings ranging from talking about computers without actually using them to using them as integral tools supporting learning. This disappointment prompted the development of his computer practice framework (CPF) based on the dimensions of quantity, focus and mode of use. This dovetails well in observing a school activity system where computers are either in use or not in use (Figure 2.7). If in use, the focus is IT, mediation tool or other.

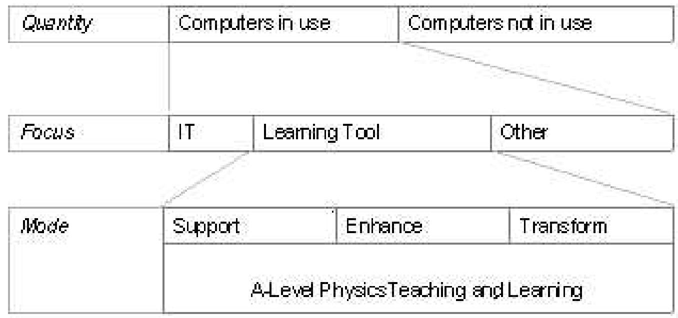


Figure 2.7 Measuring use of ICT: The Computer Practice Framework (adapted from Twining, 2003)

"Other" is not the focus in this study because it refers to computer use for objectives that do not relate directly to learning outcomes or where no learning is apparent. Two examples from Twining's list are: allowing students to use the computer as a holding activity whilst the teacher is working elsewhere and using a computer to ease pressure from students or their parents or other external agencies.

According to Twining, the "mode" dimension is concerned with the impact of computer use on the curriculum. Considering the capabilities of ICTs (section 2.7.2), use of ICT as in activity theory and as mediation tool in Physics can support, enhance and may even transform the way Physics is taught and learnt. This study is limited to ICT in use and as mediation tool for A-Level Physics. Activity theory (section 2.1) places value on use of tools in the teaching and learning situation.

Support

Within the activity system where ICT is used as a learning tool, it would support the learning effort in Physics. In the "support mode" teachers use electronic white boards, beamers (data projectors), and students use spread sheets, CDs and the Internet to mention a few. Practical work, for example, is automated as in data logging. The key characteristic is that the existing curriculum objectives are covered using ICT.

Enhance

The use of ICT would also extend the curriculum content or processes. An example is in the DOL arm of the activity system where the use of ICT may entail teaching students to be effective peer tutors so they can teach others how to use a new peripheral device or software.

Transform

Physics is one curriculum area with some processes that can only be undertaken with use of a computer. Good examples are data logging (section 2.7.3) and simulation of experiments that are impossible under normal lab conditions (sections 2.7.2,). Thus the use of ICT in such situations has a potential transformatory impact on classroom practice. Research question 5 in this study actually sought to establish how the teaching and learning environment was changing as a result of using ICT.

While the main focus in my study was on the mode of ICT use, where ICT was used to “support” the teaching and learning of Physics, it was hoped that some aspects of the “enhance” and “transform” categories would also be evident. The next section looks at how learning theories support this use of ICTs in Physics teaching and learning.

2.6 ICT, Nature of Physics and Learning theory: the synergy

To match the tool to the task, the task must be known. It is important to know the nature of Physics in order to match it to the suitable ICT.

2.6.1 Nature of Physics

Physics is simultaneously a kind of knowledge (product) and a way of investigating to gain that knowledge (process). In addition, it is a way of thinking (attitudes) (Mutasa & Wills, 1994).

The knowledge component or content comprises facts, concepts, principles, hypotheses, laws and theories. The processes can be understood as activities including problem identification, hypothesizing and experimentation, analyzing results and drawing conclusions (Mutasa & Wills, 1994). In the process of doing A-Level Physics, the students are expected to develop positive attitudes to include perseverance, creativity, curiosity, objectivity, integrity, inventiveness, and cooperation (UCLES, 2000; ZIMSEC, 2003).

2.6.2 The challenges of teaching and learning Physics

The A-Level Physics curriculum poses enormous challenges to both the learner and the teacher. The learner has to grapple with the abstract concepts concerning the universe, ranging from the determination of the size of the invisible sub-atomic particles in nuclear Physics to the magnitude of large bodies such as components of the solar system and galaxies in the universe. In school laboratory experiments students have to deal with numerous measurements and values mainly in figures. Measuring instruments and related apparatus, calculators, graph paper and pencil are some of the traditional tools in practical work. Often students struggle to strike a balance between data collection processes where measurement values of fast moving objects are required with repeated readings and at the same time maintaining a record of results, drawing graphs and analyzing the results.

ICT may not be a panacea to all these challenges, but can be a versatile tool for dealing with both the content and process of Physics.

2.6.3 Learning theories support ICT use

It can be shown that the use of ICT in the teaching and learning of Physics is underpinned by a range of learning theories. From among many models of ICT use, the educational paradigms for computer assisted learning (CAL) developed by Kemmis, Atkin and Wright (1977 in Skaife and Wellington 1993) date back to the advent of computers in education. Their framework is a suite of four paradigms; the instructional, the revelatory, the conjectural and the emancipatory paradigms. These can be twinned to the key schools of learning theory:

1. Instructional paradigm –behaviorism
2. Revelatory paradigm –cognitivism
3. Conjectural paradigm –constructivism
4. Emancipatory paradigm –all +social constructivism

2.6.3.1 Instructional paradigm–behaviorism

> The primary function of PLATO was to produce a rich environment in which trainers could create and deliver high quality interactive courseware to students in classrooms, homes and offices with or without the presence of an instructor (Szabo, 1992:7).

Historically, behaviorism has had the greatest influence on the design and use of ICT (Simonson & Thompson, 1997). It was on the basis of a behaviorist model that the Programmed Logic for

Automated Teaching Operations (PLATO), one of the first Computer Based Instruction systems, was developed (Merrill, Hammons, Vincent, Reynolds, Christensen & Tolman, 1996). Based on Skinner's operant conditioning and Pavlov's classical conditioning, the essence of behaviorism is to have instruction that produces behavioral change (Simonson, 1997). In this model the role of the computer is to present the content, test and give the student feed back. The computer is used as a patient tutor (Taylor, 1986; Williams, 2000). Software developed designed under this framework carries names such as "skill and practice" or "drill and practice" (Skaife & Wellington, 1993:24).

A-Level Physics students may find "drill and practice" software useful where in terms of content, the syllabus still requires many facts and principles to be learnt in addition to calculations that need repeated practice. These syllabi still include *recall and use* assessment objectives (UCLES, 2000; ZIMSEC, 2003). However one predictable drawback of the use of "drill and practice" software would be the need for bespoke drill and practice software that the non-programmer teachers may not have the skills to produce, while outsourcing to professional programmers would be exorbitantly expensive, especially in an economically challenged country such as Zimbabwe.

2.6.3.2 Revelatory paradigm – Cognitivism

While the behaviourist focuses on the content as the object of learning, the cognitivist pays attention to the student as subject (Simonson & Thompson, 1997:42) and the computer as a mediator (Skaife & Wellington, 1993). The student is guided to learn through discovery. The learner is also given opportunity to learn through concrete operations, and then graphical representations of reality before engaging with abstract numerical symbols. The role of ICT is to provide a rich learning environment. Software programs that fulfill this include simulations, multimedia encyclopedia, and electronic books (Williams, 2000).

2.6.3.3 Conjectural paradigm – Constructivism

It has already been mentioned that Physics is both a domain of knowledge and process of investigation. Constructivism elevates the importance of processes especially the knowledge construction process. Advocates of constructivism, Piaget (1981) and Bruner (1990) in Williams (2000), stress that individual constructs are developed through discovery. Students are therefore given opportunity to manipulate ideas, generate and test hypothesis (Skaife & Wellington, 1993).

ICT, in this case assumes the role of a tool especially for model building. Students can build their own models or use generic ones.

Going a step further to Vygotskian social constructivism, which pays attention to context of knowledge construction, ICT is particularly useful as a tool mediating among other learners, parents and teachers. The teacher’s main role is to provide scaffolds in the learning process, to guide, to coach the student who actively engages in constructing knowledge individually and socially. ICT plays the mediation role, providing informative tools, communication tools, constructive tools, and co-constructive tools (Williams, 2000)

2.6.3.4 Emancipatory paradigm

This paradigm involves using ICT as a labour saving tool, reducing inauthentic labour (Skaife & Wellington 1993; Twining, 2001). In A-Level Physics examples of tasks that students may relegate to the computer are many and may include laborious calculations, painstaking data capturing in selected experiments and arduous drawing of graphs. This frees time for higher-level cognitive tasks such as the interpretation and comparison of experiments.

In many respects this is also a transformatory paradigm where students are able to do things with ICT that would otherwise never be possible. Physics teachers would know the impossibility of coming up with frictionless environments for experiments in mechanics. ICT tools can simulate these. In a way this helps us to address one of the greatest challenges in the 21st century: how to harness ICTs to help us prepare for “an unknown future” (Barnett 2004:247).

2.7 Why use ICT in Physics?

The first electronic computer (court case decision) was a device constructed in 1939 for the purpose of carrying out computations related to Physics by John Vincent Atanasoff of a Iowa State University (Merrill et al., 1996:55) The laborious computational demands of Physics that necessitated the invention of this tool inclines one to follow up how ICT has been used, is being used and will be used in Physics in future.

2.7.1 Growth of ICT capabilities – opportunities

Greater opportunities in the use ICT in Physics teaching/learning have been opened up as never before as a result of growth in development of ICT. For example today's personal computers (PCs) are well over hundred times faster and more capacious than cumbersome machines installed in classrooms in the early 1980s. Due to vastly improved interface design, they are also easier to use – user friendly (Smith, 1992). Input devices such as the mouse, with the combination of graphics user interfaces have contributed to the user-friendly environment. In addition the microcomputer can take more peripheral devices such as data loggers for microcomputer based laboratory (MBL), cameras, scanners, LCD projectors to mention a few. With USB port connections, these devices are supported without need of specialized ports. Object oriented programming languages such as *Java* (http://www.java.com/en/) have made it possible for the use of Physics java applets - screen animations for visualisation of abstract concepts and phenomena.

2.7.2 Multiplicity of capabilities

Many claims have been made about what the computer can do; some of those specific to Physics are outlined:

Informative tools - Physics CDs, DVD, multimedia encyclopedia and the Internet all make a repository of information at the exposure of the Physics learner/teacher.

Communication tools – e-mail electronic bulletin boards, chat, electronic white boards, local area networks, are examples for providing Physics teaching /learning forums for teacher-student, student-student links.

Constructive tools – word processing for making Physics reports, web editors, spreadsheet, simulation and multimedia authoring tools are all useful tools. Most relevant to current A-level Physics teaching /learning and for this study are spreadsheets because of their inbuilt characteristic that allows for manipulation of numerical data and modeling (Williams 2000:194).

Simulation - are useful and valuable. Research has shown that computer simulations are valuable both in helping teachers design and conduct experiments that are supplementary to real experiments allowing students to vary parameters that cannot be varied in real laboratory environments (Jimoyiannis & Komis, 2001; Voogt et al., 2003 section 2.8.4). Skaife and Wellington (1993) devised categories of simulations and these can be adapted to Physics in the following manner:

- *Direct copies of existing laboratory activities* – pendulum swing, electric circuit board;
- *Simulation of industrial events and process* – rocket taking off (Newton third law of motion);

- *Simulations of experiments* – for example those that are too dangerous, too slow, too fast (collision in Newton's 3rd law), too small (determining size of the nucleus of an atom);
- *Simulation of non-existent entities* – ideal gas experiments, frictionless elastic collision;
- *Simulations of models of theories* – kinetic theory, the wave nature of light, EM field simulation (Skaife & Wellington, 1993; Redish, 1993).

Theoretical advantages have been cited for these which include cost effectiveness, time, safety, motivation for students and easy of control of variables. Cognitive gains have been recorded with students' misconceptions being ironed out (Jimoyiannis & Komis, 2001). While there is room to look for more empirical evidence of these advantages, this study focuses on the extent to which these capabilities are used in A-level Physics.

2.7.3 Data logging

This involves linking a sensor /probe to a computer to capture and view data either as tabular or graphical form on the computer screen. One beauty of data logging is that data is available in real time. Its major advantages are the high sensitivity for measurement of very small changes and the ability to monitor changes over a very short or a very long period of time (Ng & Yeung 2000). It is also one application that frees the student to engage in higher order thinking skills – analysis and discussion of the data. However, this emancipatory role that takes away the opportunity from students of doing the data collection manually does not appeal to some teachers and opinions are divided on this point. This might be one reason why although data logging has so much to offer in Physics, its use is not wide spread (Skaife & Wellington 1993:62; McRobbie & Thomas, 2000:156).

The next section looks at how these ideas have been implemented.

2.8 ICT implementation in schools: The extent of use.

2.8.1 Presence of ICT in schools

ICT infrastructure in a school is understood to comprise a basic computer system configuration with a systems unit, monitor, keyboard and mouse together with generic operating system and application software. Some schools have gone beyond the basic configuration and have added connectivity and additional peripheral devices such as multimedia speakers, CD ROM drives, scanners, and data view projectors, etc.

These have been and are being used variously by teachers and students. There are a number of indicators of use, student to computer ratio being the basic one. Another way is to group several indicators together and consider an overall picture of use. The Organisation for Economic Co-operation and Development (OECD) data in Figure 2.8 gives the frequency of use of computers by students in schools across several countries. On average there were more students who used computers at home than those who did not. The contrary is true at school. In general students tended to use computers more at home than at school.

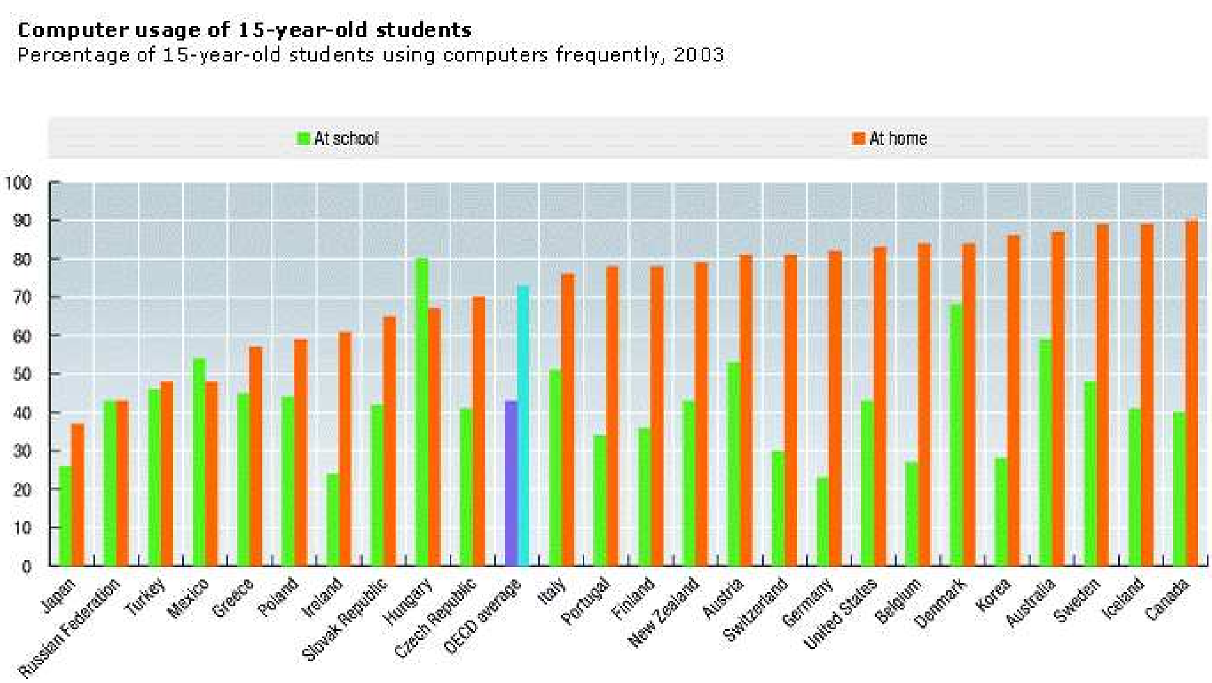


Figure 2.8 Computer use by students in selected countries

http://titania.sourceoecd.org/vl=2706492/cl=30/nw=1/rpsv/factbook/09-01-01-g02.htm

Date accessed: 14/6/2007

However the OECD data focused on developed and medium developed countries. It would be interesting to find out how the developing countries compare.

Using the student-to-computer ratio indicator, for example Rodrigo (2005) compared deployment and use of personal computers (PCs) in Metro Manila with Norway representing the developed countries and South Africa and Russia for the medium development category (Table 2.5).

Student–computer ratios for secondary schools in Metro Manila and upper secondary schools in IEA-surveyed countries

	A. Total students divided by total computers	B. Total computer-using students divided by total computers
Metro Manila	54.8	18.6
Norway	5.8	4.0
Russian Fed.	22.4	12.5
South Africa	6.1	1.3

Percentages of secondary school students in Metro Manila and upper secondary schools in IEA-surveyed countries whose schools have access to the Internet for instructional purposes

	Access to the Internet
Metro Manila	46
Norway	98
Russian Fed.	4
South Africa	60

Table 2.5 Student to computer ratios and access to Internet (Data from Rodrigo (2005: 59-60) Table 4 & 7)

In choosing the comparison countries from the International Association for the Evaluation of Educational Achievement (IEA) data, Rodrigo (2005) excluded the lower level representing the developing countries where we would find Zimbabwe. Still the computer to student ratio was found to vary even within countries in the same human development index (HDI) category (http://en.wikipedia.org/wiki/Human_Development_Index). For example South Africa which is in the same middle development level as the Russian Federation and Metro Manila has very comfortable student-computer ratios of 6.1 in general and 1.3 on use compared to the other two (Table 2.5). On use of the Internet for instructional purposes, Norway representing the developed countries boasts of 98% access while Russian Federation is on the ebb with 4%.

2.8.2 Level of use of ICT for teaching and learning

This section highlights how ICT has been used is teaching and learning in schools in general. Two examples are described one from the west and another from the east. The first example is taken from the United Kingdom. Deaney, Ruthven and Hennessy (2003b) explored pupils' views on the use of ICT within subject teaching and learning in six English secondary schools. They used a cohort of three-year groups (year 8, 10 and 12); appropriately choosing focus group interview for methodology. Their data analysis of 27 interviews had to include the use of the computer package NUD*ST. The majority of the pupils had access to home computers. The reported ICT tools that were used across the subjects included word processors and publishing packages, calculators, CD-ROM encyclopedias and the Internet. For more specialized curricular subjects graphing tools were used in Mathematics, data logging in Science and electronic circuit simulations in Science and Technology. General courseware in form of puzzles, games, drills and revision packs were also in use. Overall their results yielded six organisational themes. The *tasks effected* theme related to pupils' appreciation of ICT enabling them to carry out certain academic tasks "easily, quickly and reliably" (2003b: 161) and simultaneously outputting high quality work. However in some cases potential was hampered by lack of proficiency in using the tools. The second theme of *refinement assisted* emerged from pupils articulating how the computer helped them to correct and make revision to their work; trialing without blowing it up, modifying work, spelling and grammar checking, reorganising text and exploring various patterns in graphs from equations. With the third theme *ambience altered* pupils also associated use of ICT with a change in working environment, having lessons in computer rooms, with different tools (other than pen and paper).

Among the other changes the pupils also saw was their interaction with each other and with the teacher. In ICT mediated lessons the teacher gave individual attention to pupils. The interaction with pupils became less formal and less rigid. In terms of the pupil-pupil interaction there was more informal chatting as they worked mostly in pairs to a computer.

With the fourth theme *motivation changed* pupils associated use of ICT with fun and enjoyment and deliverance from tedious tasks. On the other hand motivation decreased when the computer "did it", stealing the opportunity from the pupil to actively engage in a task. Motivation was also reduced where the task demanded a computer skill that the pupil was not good at.

The fifth theme, *learning reshaped* was a collection of pupils views of ICT being more than a tool but "something too learn with."(2003b: 161). Very popular with pupils in this category were *revision software* and websites that addressed learning objectives. What they liked about revision software was getting quick feedback. The strength of courseware software was pupils being enabled to go back over and over what they did not understand. The use of simulations was seen as helpful in grasping of concepts. This happened where the simulation experiment allowed the pupil to change variables and observe the net effect:

> It was electron acceleration or something. Rather than show a picture from a book he was able to show us a simulation of what was going on and so I think that helped quite a lot. / We had to type in different values for a magnetic field and electron charges and you could see what had happened and what you did. That definitely helped. [MC/12]
>
> (Deaney, Ruthven & Hennessy, 2003b: 156)

Finally teaching *displaced* dealt with how the pupils viewed the teacher's role within the ICT mediated lessons. There were indications that the teacher's role in "orchestrating the academic, technical and social aspects of the classroom experience"(Deaney et al.., 2003b: 161) could be eroded.

The second example is taken from China where Ng and Yeung (2000) explored the views of students and teachers on the implications of data logging in A-level Physics. The Nuffield advanced level Physics syllabus, required students to follow given sets of instructions in practicals to obtain sets of data and produce a graph as the end product. From their graphs the students would merely extract intercepts and slopes. Ng and Yeung (2000) undertook trial activities that would see the more desirable way of doing Physics; using practicals not only for psychomotor skills, but also for the higher order ones of testing hypotheses. They chose to use three experiments with data loggers: the bouncing ball experiment, centripetal force of a pendulum and resistance of a bulb filament. Six groups per class worked in groups of 3 or 4 for less than an hour on an experiment. Their teacher had 18 years experience. Forty-one students completed a questionnaire with Likert-scale type questions after the first experiment. Only one learner out of these did not have a PC at home. Two weeks latter the other two experiments were done followed by an interview.

The salient findings that emerged and that would have a bearing on the Zimbabwean experience follow: There were mixed feelings from the students on use of data logging. First the question of its relevancy to examinations was raised; automation of data collection and processing was an amazing innovation giving the same end product - a graph. The difference being that the computer produced a better one, more accurately and produced it in much less time. This became a threat to the student because the computer had taken over the student's role. The major problem was that the examinations would go on to test the student on skills that were done by the computer! This clash of interest warrants further investigation. It would seem that the advent of use of ICT is likely to force transformation on curriculum. However, both syllabi objectives as well as assessment objectives would need to change.

From the teachers' perspective the following laboratory management concern is worth mentioning:

> It is easy to use another stopwatch if it goes wrong in a conventional experiment. However there is little a teacher can do if something goes wrong in a data-logging experiment (Ng & Yeung 2000) http://www.ied.edu.hk/apfslt/issue_2/phng/phng5.htm

Ng and Yeung predicted that this would hinder those teachers with low IT competency from experimenting with data-loggers.

Another factor likely to have a bearing on adoption of ICT as mediation tool is examination pressure. Ng and Yeung (2000) report on a case from a data-logging pilot school where students performed the motion experiments with both the data-logger (because it gave better results) and the *ticker-tape timer* (because this was stated in the examination syllabus). However, despite the challenges students were optimistic about the use of Data loggers as captured in what they said:

> The sensors are very sensitive and they can measure something we can't measure before.
>
> The plotting of graph manually is really tedious. I like the graphical function of the software and the graph is indeed very smooth.
>
> The data is very accurate and I like the software can present several sets of data on the same graph.
>
> (Ng & Yeung, 2000). http://www.ied.edu.hk/apfslt/issue_2/phng/phng5.htm

2.8.3. Projects on use of ICT in Physics

This section gives snapshots of ICT use that has yielded positive outcomes /good practice.

MBL

Microcomputer-based laboratories (MBL) have been successfully used in University introductory Physics for instance in Newtonian mechanics with the effect of a shift from lecture method to student centered "brains on" activities. Students work in groups, collect data, make predictions, and make comparisons with screen graphs (Thornton & Solokoff, 1990 in Redish, 1993; Redish, Saul & Steinberg, 1997).

Experienced high school Physics teachers have used the same MBL with students to capture and graph data such as in kinematics. Students observe, predict, interpret graphs, create Maths descriptions, explanations and make white board presentations in class discussions (Kearsely, Hunter & Furlong, 1992:68-70). Again the teaching methods of the teachers who use MBL tend to be more student-centered than teacher-centred. A case in point was the use of a simulation of oscillatory motion by Kelly, Crawford and Green (2001), with four groups of grade 12 learners to construct Physics. They used an ethnographic approach to study the construction of science in small laboratory groups Their approach focused on examining cultural actions, artefacts, and discourse processes through which group members constructed social situations. They observed that "the construction of physics tasks by the different student groups involved more than doing, talking, and knowing physics; it also involved establishing and maintaining positions and relationships within the group." Their results showed "how a common task led to differential contexts for learning physics, […] and to the development of different opportunities for learning physics" (Kelly, Crawford & Green, 2001:135).

MBL technology has also been used for example with a 486 MHz computer in tandem with pressure and temperature sensors for Boyle's Law experiments with year 11 classes at Metropolitan Independent School in Brisbane Australia. This was however within a research set up which yielded the result that there is potential in use of MBL, but its implementation depended on the teachers and student beliefs regarding teaching and learning; this could pose a major obstacle (McRobbie & Thomas, 2000).

The CPU Project
In another research initiative the Constructing Physics Understanding project (CPU), in the USA, high school Physics teachers attended staff development workshops in pedagogy to teach in CPU classrooms. Students were to use sets of computer simulations and electronic journals to develop, test and modify ideas through experiments and discussions with peers (Huffman, Goldberg, & Michlin, 2003).

Table 2.6 The three groups of teachers in the CPU project

Three groups of teachers participated:

1. The comparison teacher had access to computers in the media center but rarely used them.
2. The beginning teacher faced challenges like getting the simulators to work on different platforms, having to handle a full class with a small number of computers and from students demanding right answers without delay.
3. The lead teacher had simulators and MBL speeding up data collection, freeing time for students to test more ideas. The teacher's role was that of coach.

About the CPU project, Mzoughi, Herring, Foley, Morris and Gilbert (2007) testified: "The CPU Light and Color unit of this curriculum is very effective in helping students to forgo their misconceptions of some of the topics, and in building a solid understanding of the topics covered." They go on to say that "the CPU curriculum is a commercial product intended for high school teachers and students" (2007:112).

Workshop Physics
Workshop Physics is another successful project for the use of the computer as a flexible and general purpose tool comprising of graphers, spreadsheet, lab tools and video tools (Redish, 1993) The Workshop Physics project at Dickinson College "represents an attempt to redesign the teaching methods in introductory physics courses to take advantage of recent findings in physics education research and introduce students to the use of modern computer tools" (Dickinson College, Physics Department. 2004, August 10).

The Internet
Several projects have been undertaken for use of the Internet in teaching and learning Physics. One example is *schools on-line* (UK), developed initially for students and eventually as a forum for teachers (Skinner & Preece, 2003). In another setting Deaney, Ruthven and Hennessy,

(2003a) examined how teachers incorporated use of Internet resources and related ICT tools into their subject areas. Voluntary participants were interviewed and also reported on small-scale school-based projects on use of Internet resources in lessons. Most important features that emerged from these projects were the relocation of lessons to pre-booked ICT rooms, pupils having to work in pairs due to limitations on the number of computers available, overcrowding in some rooms and computer suites. At times network failures disrupted lessons.

The third example is about a web-based resource for Physics. Anyone who has taught or learnt Physics would bear witness to the challenges in the topic optics and waves. A web-based interactive computer graphics system that simulates optical and wave phenomena called *WebTOP* has been developed and implemented currently in more than twenty universities in introductory Physics classes (Mzoughi et al*.,* 2007). Reading between the lines, one thing that is of significance is collaborative effort and skills mix in the authorship of *WebTOP,* which includes three members from the Department of Physics and Astronomy and two members from the Department of Computer Science and Engineering. The following excerpts highlight the characteristics of the product. (Mzoughi et al., 2007:123-124)

Table 2.7 WebTOP Characteristics

WebTOP is Web-based interactive computer graphics system that simulates optical and wave phenomena. Its purpose is to help students and teachers better understand these phenomena through 3D visualisation.
The ability to change the values of all the relevant parameters in a simulation allows the instructor to show, in real time, the effect of changing each parameter in a way that can be clearly seen by the students, even in large lecture halls. *WebTOP* can be used in addition to, or instead of, regular equipment-based demonstrations.
Furthermore, *WebTOP* can be used for homework. Students can use *WebTOP* to help verify the answers they get in regular end of the chapter problems. Additionally, teachers can assign some of the suggested *WebTOP*-based problems provided in the ''Exercises'' section of the modules. In this case, the students can be asked to analyze certain situations, produce numerical or qualitative answers to questions, and then use *WebTOP* to simulate the situation and check their answers. Homework can also take the form of an online tutorial. Students can be asked to learn about a particular topic by completing an online *WebTOP* guided tutorial. The tutorial can be assigned before or after lecture instruction.
WebTOP can also be used to supplement laboratory activities. It can be used in pre-lab activities to help explain the phenomenon that is going to be investigated in the lab. It can be used during the lab to compare actual data to the simulation results and to help draw inferences when equipment limitations occur. For example, a student can run a laboratory on the interference of light from two slits, and at the same time simulate the situation using *WebTOP*. *WebTOP* will allow him to see the slits being moved as he pulls on the widget attached to one of them, thus building his intuition about what will happen. Secondly, *WebTOP* allows him to vary certain parameters (e.g. the wavelength of the incident light) that are difficult to vary in the actual lab.

Finally, *WebTOP* can be used for student projects. Students can work in teams or individually on particular problems and use *WebTOP* to help illustrate their presentations and reports.

Adapted from (Mzoughi, Herring ,Foley, Morris & Gilbert 2007)

It is noted from the extract that *WebTOP* is a versatile tool, which can bring about variety within the activity system of the Physics laboratory being able to supplement other learning tools like lectures, homework, laboratory activities, and demonstrations. Of significance is the fact that *WebTOP* does not have to replace the existing teaching/learning framework, but rather comes in as a support tool. Considering the activity system (section 2.2.2), the subject (student) is afforded the opportunity to interact with the object (Physics concept). This brings about some ray of hope to the long-standing aspiration for student-centred learning where student teams enhance collaborative learning and adequate DOL within the community.

According to Mzoughi et al., (2007), by collecting end-of-semester student surveys from students at Mississippi State University and informal feedback from teachers, it emerged that “teachers spoke very positively about *WebTOP* and the way it helps them demonstrate important concepts” (Mzoughi et al., 2007:125), Some noted that, since adopting *WebTOP*, “they have noticed a distinct performance improvement” (Mzoughi et al., 2007:126).

While there are these innovations in use of ICT in teaching and learning of Physics, these seem to remain in the hands of those who initiated them and especially within universities. There is still a narrow spread of reports of the same nature and their use in schools. An example of best practice within a secondary school setting follows.

2.8.4. Success stories: Examples of best practice

Best practice in using ICT is estimated in the current study to be an appropriate integration of ICT in the teaching and learning of Physics. It would entail a careful choice of computer artefacts backed by learning theory for the enhancement the student’s learning of Physics.

Two snap shots of Physics lessons that integrate ICT as a teaching/learning tool are taken from a Russian rural school (Voogt, Gorokhovatsky & Almekinders 2003:70), Tables 2.8 and 2.9. In my opinion these are examples of best practice for the innovative ways in which the teachers used computers. Not only did the teachers use simulations for Physics experiments that are usually impossible under normal lab conditions but they went ahead and used simulations side by side with real experiments allowing students to make comparisons. Students also got opportunities to carry out investigations in line with the scientific method and in the process the computer was used as a measuring tool. Students were actively engaged in a variety of activities in any one lesson. In all this the teachers had clearly stated objectives and some of their objectives that went beyond students’ knowledge acquisition were:

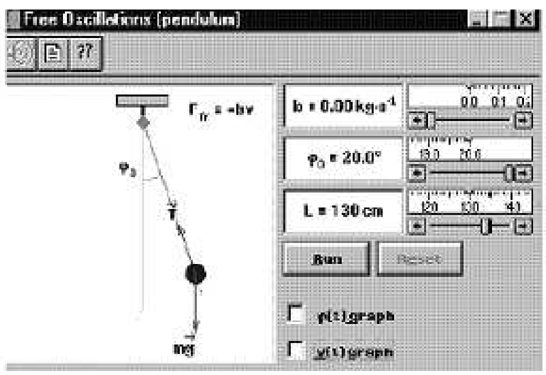
- To increase the development of research skills through working with physics instruments and computer models.
- To develop students' logical thinking to improve their ability in drawing inductive conclusions.
- To develop the skills of working in small and large groups.
- To develop personality characteristics such as the aspiration for collaboration and mutual aid. (Voogt, Gorokhovatsky & Almekinders, 2003:56-57)

Table 2.8 Exemplar Physics lesson 1

In the following lessons, an increase in the use of the simulation programmes and other applications of IT in physics can be seen in the form of experiments in which the computer is used for carrying out measurements and for demonstrating and analysing data. In this lesson, measurements of a pendulum an vibrating spring are carried out with a stopwatch; the other group carries out these measurements with the help of a computer set-up (relay releases mass and starts measurements, mass passes through photodiode and a signal is sent to the computer which counts periods); the third group simulates the experiments

Oscillation the pendulum and the period

The measurement of g



This lesson (90') consists of two parts: a computer simulation and a real experiment with a mathematical pendulum. The lesson starts with a discussion about the pendulum, period and variables related to the period. A short test (seven questions) is conducted to ascertain the pupils' pre-knowledge. The pupils and the teacher then focus on the mathematical expression they will be using, namely,

the formula T = 2πϖ(√l/g) to calculate g after the measurement of the period T. In the first part of the lesson, the pupils play with the formula in a simulation (Programme: Open Physics). Eleven pupils work individually for about twenty minutes with the help of a worksheet. The worksheet concretely informs the pupils what they have to do: length of pendulum, amplitude, measure period, change length of pendulum and measure period. They have to calculate g in both cases. After the individual work, the pupils discuss their results in three groups and together with the teacher, summarise the simulation. After a short break, the pupils start to do the real experiment in groups of 3-4 pupils. The small groups measure the period with the help of a computer measurement (L-mikro) and the other two groups measure it with a stopwatch. The pupils write their final results (period T and value of g) on the blackboard. At the end of the lesson the results are compared with the 'real value of g'.

Willem Bustraan in Voogt J, et al (Eds.) 2003:70

Sometimes the use of a computer simulation is the only possibility, when equipment is not available or when an experiment is too complicated for the school environment. What follows is an example of the later.

Table 2.9 Exemplar Physics lesson 2

Simulations of 'difficult' experiments

Coulomb's Law
Via a number of small experiments (charged poles and strips of paper) the pupils' interest in the electrostatic phenomenon is stimulated. The teacher tells them how difficult it is to measure quantitative charges and forces; which is why they will carry out a simulation experiment to check Coulomb's law. The pupils work in pairs with the simulation and a worksheet. The values of the charges and the distances, which have to be set, have already been given on the worksheets; the forces have to be read off the screen and filled in. After completing the table, the pupils have to check whether indeed F~q1q2 and F~(1/r2). The measurements are discussed with the teacher and the law reformulated. There is no more time for discussing the lesson, which is a pity because the teacher had prepared this in advance.

Willem Bustraan in Voogt J, et al (Eds.) 2003:70

These examples from Russia show how ICT can become part and parcel of the Physics teacher's tools fully integrated into the daily lessons. Bustraan (in Voogt et al., 2003:72) concluded that, "Russian teachers are creatively engaged in using the computer and are fully aware that they must devote considerable attention to the appropriate teaching methods for using it". Simulations offer the pupils extra support for learning concepts and laws, and can replace experiments, which are difficult to conduct. Simulations can be used most successfully in conjunction with a real experiment. The quoted lessons reflect this and demonstrate the way in which the computer can enrich the pupils' learning experiences.

The next section reflects upon the Zimbabwean experience of using computers to enhance teaching and learning.

2.9 The Zimbabwean story

2.9.1 The use of ICTs in education

The boom period for the advent of computers in schools in Zimbabwe may be unknown, but an intelligent guess can put it at 2005 when computers were moved in hundred fold to each province and in tens to selected schools through a presidential initiative. Of course before that there were other initiatives. For example Cawthera (2000) classified provision of computers in schools in Zimbabwe and South Africa (SA) into 3 types namely: *Basic provision, basic plus* and *deluxe provision.* This meant that deployment of computers in schools varied in terms of numbers and capacity. Basic provision for example depended on [6]NGO donations of second hand computers. These were usually low speed 486 refurbished desktop computers and initially as few as 4 per school. On the other hand *deluxe provision* installed refurbished and in some cases new equipment for well-resourced schools. In one such school 65 Pentium3 computers in purpose built labs and tailor made furniture were found in place. This was the state of affairs as in 2000. It was therefore worthwhile for this current study to describe the situation as it is now.

Furthermore Cawthera's study focused on cost of provision but generalized on use of the available ICT. He guessed that the actual use could be 20-30% of availability. The purpose for which the ICT infrastructure is used was not specified except for Bishops' College in SA, where there is mention of the intranet for research by students. Therefore it would seem that in Zimbabwe it is yet to be established what existing ICT infrastructures in schools are being used for.

[6] None Governmental Organisation

2.9.2 Use of ICT in Science teaching in Zimbabwe

Zimbabwe was one of eight Sub-Saharan African countries studied as part of the SMICT[7] project focusing on instructional practices (Ottevanger, Leliveld & Clegg, 2003). It was noted that:

> … Calculators, computer and ICT, videodisks and other electronic media are not being used much in schools for concept development. The emphasis is still on specific media literacy skill acquisition. ICT is rarely used as part of teaching and learning materials, not even in private schools where resources are comparatively abundant. Teachers regularly use ICT for lesson preparations but hardly in actual teaching. Use of ICT in practical work is still a dream for schools in Zimbabwe (Ottenvanger, Leliveld & Clegg, 2003:10).

Considering the low level of usage of computers hypothesised by Cawthera (2000) and generally the rare use of ICT in teaching and learning suggested by this quotation, one could only be curious about how ICTs were deployed in the schools and the specific uses to which they were put. This study singled out A-Level Physics teachers and their students in an effort to discover the prevailing reality in a Zimbabwean school.

2.10 Summary

This chapter identified activity theory as the most suitable theoretical framework for the study of use of ICT in education. Within this framework the challenges faced by Zimbabwe in its education system past and present were chronicled in the light of Commissions of enquiry. Among the challenges identified was that of teacher's methods that remained traditional and geared towards drilling students for examinations. The use of ICT as a mediation tool that would improve the quality of teaching and learning was explored in the light of learning theories. It was shown that indeed learning theories support use of ICT. Physics is one area where there are countless opportunities of integrating ICT in the teaching and learning process. The extent to which Physics teachers globally, have taken up these opportunities were highlighted. The pointers are that in the 21st century the boom of use of ICT in the teaching and learning of Physics is imminent.

The next chapter will make overt the philosophical assumptions that underpin this study and explain and justify the research design choices in the light of these assumptions.

[7] Science, Mathematics and ICT

Chapter 3 Research Design

What one wants to learn suggests how one should go about it
(Trauth 2001 in Dobson, 2002:6).

3.1 Introduction

The research design decisions were based on what was to be studied: the use of ICT in the teaching and learning of A-level Physics and where it was to be studied: the schools in Manicaland, Zimbabwe. This chapter firstly explains the philosophical underpinnings of the research design. Secondly the choice of the case study approach is discussed. Thirdly particular attention is paid to how the participants were selected and how site visits were carried out. Fourthly data collection procedures are laid out and these include how the research questions were related to the chosen methods. The construction and composition of the three questionnaires that were used are described followed by an explanation on the use of informal interviews. Fifthly the steps taken towards validating the instruments are discussed. Lastly data analysis methods are explained before looking at the processes undertaken to verify the findings.

3.2 Research Paradigm –Critical realism

… Reality does exist but that it can be known only imperfectly…
(Mertens, 1998:9).

Mertens' words reflect a critical realist perspective that reality exists independent of our knowing of it, and that our knowledge is fallible (Sayer, 1992). The critical realist perspective is useful in this study in that it acknowledges the existence of an independent reality 'out there' that can be explored. In this study that reality is seen as embodied in the structures, the mechanisms and events (Sayer, 1992) within society at large, the education system and the school system in which the use of ICT is taking place. The observable events such as teaching, using computers, presenting projects, etc. emerge from and would not exist without underlying mechanisms, which in turn are rooted in structures.

The model attributed to Sayer (1992) as explained by Dobson (2002:2) (Figure 3.1.) is adapted here to show the levels of reality in natural or social settings.

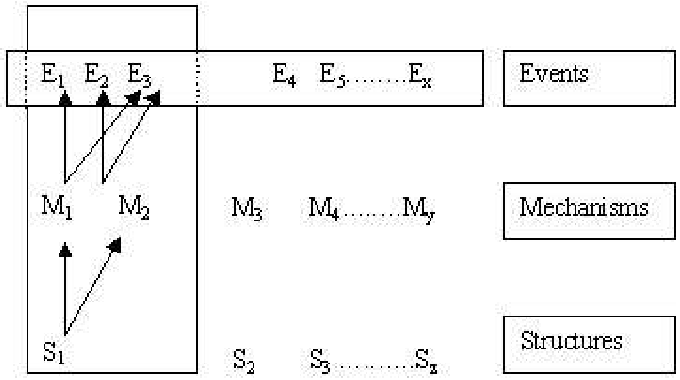


Figure 3.1 Structures, mechanisms and events (adapted from Sayer 1992 in Dobson 2002:2)

If the study were merely surveying ICT activities undertaken by Physics teachers and learners, it would suffice to just define a methodology to study events at the level E to as many as E_x in the use of ICT. Based on this critical realist perspective this study goes deeper than the events observable at the surface to the mechanisms (M_1–M_y) causal to such events and the structures (S_1-S_z) from which the mechanisms emerge. To this Benton & Craib (2001:132) say, "Structures are causally efficacious in that they both enable actions which would otherwise be not be possible" [e.g. Internet connectivity] "and constrain actions" [e.g. lack of bandwidth provision.]. To this effect critical realism becomes a useful tool for deeper analysis so that when patterns emerge from the events, at the E–level, a necessary further question must follow: "What underlying mechanism or structure would if it existed, explain the pattern?" (Benton & Craib, 2000:122.). For this reason this study on the use of ICT in teaching and learning of A-level Physics, takes the route E through M to S (Figure 3.1). The realist refers to this pathway as intensive research (Sayer, 1992 in Dobson, 2002:9), which pays attention to "particular contexts and combinations of isolated structures, mechanisms and actual events " (Dobson, 2002:8). While Sayer's model in Figure 3.1 is applicable to both natural sciences and social sciences, the structures in the social ontology are less enduring (Benton & Craig, 2001:132). Thus some structures involved in the study of the use of ICT in teaching /learning are subject to modification with activity, with time, and with the concept or view of the actors (Benton & Craib, 2001:133).

The critical realist holds that what is to be studied suggests how it should be studied, "the nature of what exists cannot be unrelated to how it is studied" (Archer, 1995 in Dobson, 2002:5) and as Sayer (1992:4) puts it "the choice of method must be appropriate to the nature of the object under study". As the schools in this study were envisaged to include a spectrum of poor to rich ICT environments, an apt strategy to unearth the real mechanisms and structures enabling and constraining the use of ICTs by teachers and learners would be to study them on a case-by-case basis. This afforded an opportunity for the researcher to interact with and learn from the school structures as a whole about how ICT were knitted into the system.

It is also worth noting that critical realism "argues for a relational perspective, which sees society as an ensemble of structures, practices and conventions that individuals reproduce or transform" (Bhasker, 1991 in Dobson, 2002:7). This dovetails well with the garden-as-culture metaphor already adopted as a framework in this study as described in Chapter 2.

3.3 From case-to-case: Multiple case studies

According to Stake (in Denzin & Lincoln, 1988: 435), the case study requires "a choice of what is to be studied". In this study, the case chosen was a school. To fit the definition of a case, each school was taken to be "a bounded system with a self that has a purpose and structures" (Stake cited in Denzin & Lincoln, 1988: 435). A group of cases, here referred to as multiple case studies, were undertaken in order to have each school "tell its story" (Cohen, Manion & Morrison, 2000:182), contributing to a comprehensive story of the use of ICT in the teaching and learning of A-level physics in Manicaland. As the story of each school unfolded, opportunities for identifying examples of best practice emerged.

The selection of the schools was done in a way that strove for *typicalness,* so that each case was an *exemplar* of a type of school. In the final analysis each study was therefore not only about ICT at a school, but broadly speaking, also about ICT at that *kind* of school (Best & Khan, 1993:193). Thus they speak for themselves as individual schools, but they are also a collective voice for the A-Level schools in Manicaland. This raises the possibility of making *fuzzy* generalisations (Bassey, 1999). However in doing so, one would be prudent and quick to acknowledge that: "Case study research does have its drawbacks in that it cannot be easily generalized, but if it is "contextualised and carefully described […] then others can consider its usefulness in other contexts and examples" (Wisker 2001:191). In fact social realist research explicitly holds that:

> No individual-level intervention works for everyone. No institution-level intervention works everywhere. The net effect of any particular programme is thus made up of the balance of successes and failures of individual subjects and locations. What this points to is the need for a careful look at subject and contextual difference in terms of who succeeds and who fails within any programme (Pawson, 2004:30-31).

With this in mind, the onus is therefore on the readers of this study to consider its usefulness in other contexts by drawing useful lessons from these case studies.

3.4 Selection of schools, teachers and learners

The sampling frame was the population of all A-Level schools that offer A-Level Physics in Manicaland (Appendix 6.6). The following non-probability sampling procedure guidelines were applied to select the participating schools.

- The sampling procedure was purposive (Charles & Mertler, 2002) because these schools had to be A-Level, offering Physics in the curriculum and known to have computers, although the exact number of computers was not important.
- The procedure also included quota sampling (Charles & Mertler, 2002) because the sample had to be representative of groups A, B and C schools - typical historical school groupings in Zimbabwe (Chapter 2).
- Convenience sampling (Charles & Mertler 2002) was employed because the majority of the schools had to be easily reachable (a guide of distance was an approximate radius 100 km from the City of Mutare where the researcher was based Appendix 6.6).

Ten schools were finally selected: Group A (1), Group B (1) and Group C (1 private; 7 mission) (Table 3.1). The Group A school chosen was one of the two Group A schools in the province. The second school did not offer Physics .The Group B school was the oldest of four such schools and the other three did not offer A-level Physics within their curriculum. In Group C there also happened to be only one private school (Cp) in the province. There was a wider choice on the Group C mission schools (Cm) from which the rest of the schools were chosen on the basis of proximity.

Table 3.1 Spectrum of school type and name codes of participants

Group	School Code	Physics teachers		Computer Specialists (CS)		Students	
		Number Name Code				Number Code	Name
A	S1	2	T1.1, T1.2	1	CS1	2	S1.1, S1.2
B	S2	2	T2.1, T2.2	1	CS2	2	S2.1, S2.2
Cp	S3	1	T3	1	CS3	2	S3.1, S3.2
Cm	S4	1	T4	1	CS4	2	S4.1, S4.2
	S5	2	T5.1, T5.2	1	CS5	2	S5.1, S5.2
	S6	2	T6.1, T6.2	1	CS6	2	S6.1, S6.2
	S7	2	T7.1, T7.	1	CS7	2	S7.1, S7.2
	S8	1	T8	1	CS8	2	S8.1, S8.2
	S9	0		1	CS9	2	S9.1, S9.2
	S10	2	T10.1, T10.2	1	CS10	2 S10.2	S10.1,
Total	**10**	**15**		**10**		**20**	

Three groups of participants were considered and they automatically qualified if they were the A-Level Physics teachers at the school (normally two: one teaching Form 5, the other Form 6); if they were the computer specialists in the school (the most senior was taken where there were more than one); and any two students (one Form 5 and the other Form 6) selected by the teacher or readily available.

The schools were given name codes S1 to S10. The teachers were named T1.1 to T10.2 where for an example T10.2 is the second teacher at school S10. Similarly names of participating students were converted to S1.1 to S10.2, while those of the computer specialists were coded CS1 to CS10 Table 3.1.

3.5 Visits

With permission from the Provincial Education Director Manicaland (Appendix 6.4.4), 7 schools were visited during the period 24 July-1 August 2006 and 3 schools on 5-6 November 2006. At each school, a courtesy call was made at the head's office with the letter of introduction. On reading the letter of introduction, some of the school heads made remarks about use of ICT at their school, which were captured and these contributed to the data. In most cases the researcher was then referred to the deputy head who acted as a guide to the Physics laboratory and computer room where the Physics teachers and computer specialists were located respectively. The Physics teachers in turn located the students. Informed consent (Merriam, 2002) was obtained from the participants, through the letter of introduction (Appendix 6.4.3). On average a school visit lasted 4 hours during which the first 30 minutes usually sufficed for protocol matters. However at one school, where the head was away, despite having made an appointment over the phone, the deputy head was reluctant to grant me access especially to the computer laboratory - here more than an hour was spent at the reception.

3.6 Data Collection

Data were gathered using three methods, a questionnaire, observation and interview. This is a form of methodological triangulation (Stake in Denzin & Lincoln, 1988: 443). During the visit questionnaires were distributed for completion by the Physics teacher (Appendix, 6.3.1), the computer specialist (Appendix, 6.3.2) and Physics students (Appendix, 6.3.3). Within the limits of the time available at each school, focus group discussions were conducted with the participating Physics teachers, students and the CS at S4, S5 and S10 and with students at S9.

An overview of how the research questions relate to these data generation methods is given in Table 3.2

Table 3.2 Research questions and Data generation methods

	Observation (field notes & photographs)	Questionnaires	Follow-up interview	Focus group interviews
Research question 1	Facilities Lessons	Questionnaire 1: Physics teacher Questionnaire 2: CS Questionnaire 3: Student	Physics teacher Student	Physics teacher Students
Research question 2		Questionnaire 1	Physics teacher	
Research question 3	Lessons Students' work	Questionnaire 1 Questionnaire 2 Questionnaire 3	Physics teacher students	Physics teacher Students CS
Research question 4		Questionnaire 1	Physics teacher	
Research question 5	Physics lab setup Lessons	Questionnaire 1 Questionnaire 3	Physics teacher students	

3.6.1 Observation

The school visit was an opportunity to collect data through direct contact with the environment. The ICT infrastructure was inspected to confirm accuracy of the report by the computer specialist (CS). As it proved to be the case, there were instances where the CS was not sure about some components such as network switch specifications and server software in use and computer specifications such as processor speed, memory and hard drive size. Activities in the computer laboratories were observed for between 30 minutes to one hour. Physics laboratories, preparation rooms and storerooms were also inspected for what equipment was available and whether it included ICT tools. Some photographs were taken of examples of computer labs and Physics labs. Some Physics lessons were observed and at the same time students' work inspected. Field notes were made with a column for observations where insights and reflections were recorded.

3.6.2 Questionnaires

Originally two questionnaires targeting the Physics teacher and the computer specialist were intended. A Physics student questionnaire was later added after I realized that the student is a significant participant in the ICT mediated teaching /learning system. Secondly I speculated that the data from students would be the best check on the consistency of Physics teacher's data on use of ICT in classroom practice. Besides, it was necessary to check on what teachers reported on ICT skills their students displayed. Overall the student questionnaire focused on what skills students possessed, their confidence in using ICT, their level of ICT use with teachers in class, outside formal teaching hours, and at home.

The teacher's questionnaire took on board most core variables (Best & Khan 1993). These included the A-Level syllabus, teacher competencies, ICT access issues, and presence of ICT artefacts and use of them. Knowledge and awareness of ICT tools available; their use in lessons, opinions on syllabus omission of aim 5.3 on use of IT in Physics teaching were also included.

The computer specialist's questionnaire mainly concentrated on the ICT infrastructure, presence of hardware and software, connectivity and school ICT policy issues. An overlap was allowed on questions that sought to establish what Physics resources were available and which ones were used by Physics students and teachers. This also helped to check on both the teacher and students' reports.

Questionnaire Construction

Questionnaires were tailor made for the Physics teacher, the computer specialist and the Physics student. The questionnaires were structured so as to incorporate both closed and open-ended questions. . The distribution of the questions is given in appendix 6.4.4. Questions that required yes or no responses were often followed up by those that asked for the respondent's reason for their answer.

The following steps were taken to ensure reliability of the questionnaires and that they would measure what they were purported to measure:

- *Pre testing*: the questionnaires were given to two experienced researchers in the field of ICT for their opinion. Their comments were considered and this helped to reduce unnecessary overlap of questions across the three questionnaires. All questions about ICT infrastructure were eventually put in the questionnaire for the computer specialist in the school.

- "*Dry run":* the researcher supplied possible responses. Questions were rephrased where they seemed to be ambiguous.
- *Pilot school:* One school in the one district of Manicaland (Appendix 6.5) was identified and the questionnaires were tested.

3.6.3 Interviews

The interviews were informal, first to check on the way the respondent had interpreted the questionnaire and secondly to allow the teachers and students to reiterate their views about use of ICT at their school in teaching /learning and in general. These followed soon after scanning through each completed questionnaire.

At one school, a chat with the Physics teacher, walking 500m to the senior school brought forth rich data about how he viewed the use ICT, his students, and how he viewed the use of ICT in teaching at the school. The informal nature of the interview helped in building good rapport with interviewees yielding candid and therefore valid responses.

3.7 Validity and Triangulation

In the 1970's, Denzin (1978) identified four basic types of triangulation:

1. *Data triangulation*: the use of a variety of data sources in a study;
2. *Investigator triangulation*: the use of several different researchers or evaluators;
3. *Theory triangulation*: the use of multiple perspectives to interpret a single set of data;
4. *Methodological triangulation*: the use of multiple methods to study a single problem.

Two of these forms of triangulation were used in this study:

- *Data triangulation* – three main sources of data were used namely the Physics teacher, the ICT teacher (CS) and the students.
- *Methodological triangulation* – three data gathering methods were used. These were observation, interviews (informal and focus group) and questionnaires.

This triangulation with a certain degree of overlap of questions across the CS, physics teacher and the physics student was used as a check on the consistency and validity of data.

Validity issues were further addressed by endeavouring to ensure that appropriate questions were posed, that questions avoided ambiguity and that the meanings of terms were defined. At the same time suggestions from experienced researchers such as off-loading infrastructure questions from the Physics teacher to the CS, were incorporated (Best & Khan, 1993). Trial runs were also used to refine the research instruments. Data transcriptions were completed soon after each field visit.

The next section explains how the data analysis was done.

3.8 Data analysis

The data analysis tools were limited to pen and notebook in the field and a word processor and a spreadsheet program back in the office. Write-ups of notes made in the field were done immediately to take advantage of stimulated recall on reading the notes. Initial discovery memos as well as additional thoughts memos were written during visits both in the field and during the data analysis process (Robson, 1995).

Content analysis was done based on the questionnaire and observation notes and interviews. The process was logico-inductive (Charles & Mertler 2002). The authors see this as "a thought process that uses logic to make sense of observations" (Charles & Mertler 2002:180). Key steps in the inductive process are:

- Observations are made of behaviours, situations, interactions, objects, environments
- Topics are identified from the observations and are
- Scrutinised to discover patterns and categories
- Conclusions are induced from what is observed / Explanations are made from patterns
- Those conclusions /explanations are used to answer the research questions

(Charles & Mertler, 2002:180)

Data from observations and interviews were synthesised into school case stories structured in a standard way. The stories were used later to provide evidence to answers to the research questions.

The data were organized into three master sheets created in *MS-Excel* for the capturing of data from the Physics teacher, student and computer specialist questionnaires. The spreadsheet program was chosen to enable further analysis of data of a quantitative nature. Qualitative data from field notes, interviews and questionnaires were typed in *MS-Word.* Portions of data that resonated well with that in *MS-Excel* were embedded in the appropriate places. Data from the observation notes were also transcribed into *MS-Word* forming the backbone for the case stories. Supportive data items for the stories when needed were extracted from the relevant master sheets and fused into the story.

3.9 Verification

One school where the data encoded was out of step with what appeared to be an emerging pattern across the cases was revisited. The computer specialist at this school had reported the existence of an ICT policy, use of facilities by the Physics teacher for teaching while the Physics teacher reported non-use because of lack of access. Apparently this was at a school where computers were locked away. Less serious discrepancies and gaps in quantitative data were resolved through a telephone conversation for one school. The post office was successfully used to get another questionnaire done by the computer specialist at another school after the original went missing after the visit.

3.10 Summary

This chapter has provided a description of the research design decisions taken for this study with critical realism as the underpinning philosophy. A case study approach was taken as a choice of what was to be studied. Despite the shortcoming of limited generalisabilty of findings the approach was found suitable, as it allows each case to “speak for itself”. Non-statistical sampling procedures leading to site and participant selection were highlighted. Use of different sources of data and use of different methods to collect the data through questionnaires, observation and informal interviews were explained as two ways of triangulation. The use of *MS-Excel* and *MS-Word* were described under data analysis with emphasis on use of the inductive method of qualitative data analysis.

The next chapter describes the findings from the ten school case studies.

Chapter 4 Findings

When computers are kept in special rooms, taught by special teachers, for special students, the message is that computers are not for everyone …
(Heide & Henderson, 1994:17).

4.1 Introduction

This chapter presents and discusses data from the 10 case studies through the analysis of three separate questionnaires reported on by 15 Physics teachers, one or two per school; 10 school computer specialists, one per school; and 20 Physics students, two per school. The data from the questionnaires was combined with data from observations and informal interviews undertaken during on-site visits of all 10 schools. This data triangulation helped to identify various interpretations of the use of ICTs to support the teaching and learning of Physics. The data is analysed across the cases rather than within each case.

Firstly, snap shots of the multiple case studies are given with the details kept in the appendices. Secondly, data about the ICT infrastructure across the cases is grouped into the emerging topics of availability, computer specifications, application and educational software, connectivity, location of computers, teacher access to computers and student access to computers. Thirdly, there is a brief discussion of what schools focus on in using ICT infrastructure. Seeming flaws that I termed 'fractured links' within the ICT mediated activity system are exposed. Fourthly, the Physics teachers' opinions are analysed. The extent of use of the infrastructure is grouped into use by Physics teachers and then by their students who venture into extra-school use of ICT. Fifthly, limitations to use of available ICT infrastructures in the schools were identified and centered on the emerging topics: constrictions to access, underutilisation of infrastructure, awareness, teacher competencies, teacher-CS collaboration and CS support role. Lastly observable changes in the teaching and learning of Physics with use of ICT yielded four topics: student motivation, student role as independent learner, real-life situation learning and teacher dethroned as sole provider of knowledge.

4.2 Case Stories

Stories from the multiple case studies are placed in Appendix 6.1. They were constructed under a common framework that includes the subtopics: case record, about the school, a photograph of some aspect of the school, ICT infrastructure as inspected, computer lab use, comments made during informal interviews and focus group interviews and use of computers as observed. This section provides in Table 4.1, one or two memorable things about each of the ten cases.

Table 4.1 Case Stories highlights

Case 1	5 out of 12 PC power supplies blown in a lightning bolt. Yes, there were no surge protectors in this computer lab!
Case 2	The computer lab was empty but for 1 out of 25 computers in the school. The rest were locked away in the storeroom!
Case 3	HOD IT was working on an intranet portal; the S3 school research network, pooling web-based resources for various subjects within the school curriculum.
Case 4	State-of-the art PCs in a potentially dusty environment. The two Physics students had more ICT skills than the teacher.
Case 5	The CS runs a *Linux* server with the *Encarta 2003* CD, many students busy browsing this CD. Meanwhile an outright rejection of use of ICT for teaching Physics surfaced from one of the two Physics teachers.
Case 6	The computer lab is brought to life for the sake of the Computer Studies ZIMSEC Exam projects for O-level students.
Case 7	The school with many computers, 80! Some still in boxes.
Case 8	A new computer center for the senior school. Meanwhile the junior lab computers were down, reportedly having lost power supplies to lightning strikes. The Physics teacher has ICT knowledge, but falls short of applying it.
Case 9	The 2 A-level computer Science students monopolise use of a lab with 24 computers.
Case 10	Physics students went through the Physics course “without seeing the actual things,” meaning the syllabus was covered without employing mediation tools to aid visualisation of concepts.

4.3 The Infrastructure

4.3.1 Availability and specification of hardware

The presence of suitable hardware and software is a pre-requisite for the use of ICT in teaching and learning (Tearle 2004). At the time of the audit the number of computers found in the ten schools varied from between 16 to 80 (Table 4.2). Mission schools, coded Cm, had the most computers ahead of both private schools (Cp) and government schools type A and B. The school with the least number of computers was the private school S3 with only 16. The highest number of PCs recorded was 80 computers at S7, a mission school.

Table 4.2 Number and working condition of computers in schools

School Type	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm
School	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Number of computers in the school	20	25	16	30	40	23	80	50	48	30
Number of working computers	12	16	16	28	31	15	60	35	32	30

Only at two schools, namely S3 and S10, were all the available computers in working order (Figure 4.1).

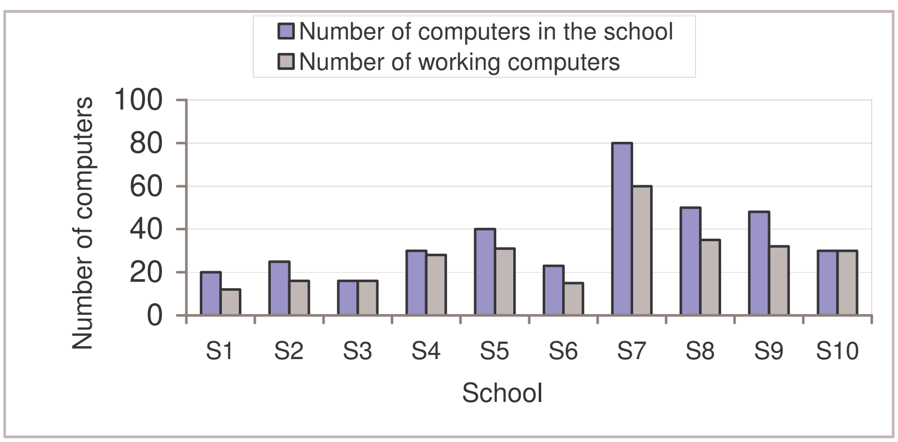


Figure 4.1 Computers working compared to those physically present

On average, six in every ten of the available computers were reported to be in working condition.

4.3.2 Computer specifications and peripherals

The system specifications of the computers included at the top of the range, 2.0 –3.0 GHz processor, 128 – 512 GB RAM and 40 - 80 GB hard drive capacity. The middle range included the 1.0 – 2.0 GHz processor, 64 – 128 MB RAM and 20 - 40 GB. The bottom range specification was the group with a 233 – 1000 MHz processor, 32 - 64 MB RAM and 1 - 10 GB hard drive. This last group was not common. In two schools computers below this last category were stored away and phased out of use. Table 4.3 provides an overview of the system configuration of the majority of the computers in a school. Where servers were available these would have a higher speed processor, bigger RAM and more hard drive capacity than the client computers.

Table 4.3 Computer specifications

School type School	A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10
[8]Processor speed	2.4GHz	2.8GHz	3.0GHz	3.0GHz	233MHz	.233/2.0GHz	500MHz	1300MHz	1300MHz	2GHz
[9]RAM	128MB	256MB	256MB	256MB	64MB	64/256MB	64MB	128MB	128MB	128MB
Hard Drive	40GB	80GB	80GB	80GB	10GB	10/40GB	10GB	64GB	40GB	40MB

The middle and top range processors were usually the standard Pentium 4 model motherboard that has inbuilt sound, Universal Serial Bus (USB) and network facilities. Most of the computers in the schools were fitted with CD ROM drives. Other useful peripheral devices common in the schools were printers. In eight of the ten schools CD-writers were also available. Less common were digital cameras available at 3 schools only and scanners also in 3 schools (Table 4.4). Data projectors have not yet found their way into the schools. One can only speculate that the cost is prohibitive or donors and other technology providers are not yet enlightened about their value in schools. All schools had each at least a 56 kilobits per second (Kbps) Modem for connection to the Internet.

[8] MHz (mega hertz) = 1 million hertz GHz (giga hertz) =1 billion hertz
[2] MB (mega byte) =1 million bytes GB (giga byte) = 1 billion bytes

Table 4.4 Selected peripheral devices

	A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10
Printers	2	11	5	4	6	3	14	8	3	7
CD ROM drives	4	16	16	30	2	26	40	20	12	24
CD Writers	0	0	1	1	2	2	2	2	1	1
Scanners	0	1	0	0	1	0	1	2	1	0
Digital cameras	0	1	0	0	0	0	1	1	0	0
Beamers (data projectors)	0	0	0	0	0	0	0	0	0	0
Modems	4	1	3	1	2	1	1	4	2	2
Data loggers	0	0	0	0	0	0	0	0	0	0

The large number of printers in the majority of the schools was generally at the expense of other peripheral devices such as scanners, beamers, cameras and data loggers.

4.3.3 Availability of application and educational software

All schools reported the availability of *MS-Office 97* or *2000* application suites, with one school having *Open Office* in addition to the *MS-Office* suite. The most common operating systems were *MS-Windows 98, 2000* and *XP*. A small selection of Physics CDs was found at five of the ten schools (Table 4.5).

Table 4.5 Physics CD titles in schools

S5	Encarta encyclopaedia (Ref Library)
	Particle mechanics
	Letts revision series
S6	A-level Physics syllabus
S7	Physics
S8	GCSE key stage 4 Physics
	GCSE Physics: Force, Motion
	GCSE Physics: waves, optics
	GCSE Physics: Matter, Earth, Stars…
	GCSE Physics: Electricity, Magnetism
S10	Revise GCSE Maths, World book

4.3.4 Connectivity: LANs and the Internet

Apart from one school, S1, the rest had local area networks (LANs) in place. Of the schools with LANs, only those at S3, S5, S6, S8 and S10 were up and running (Table 4.6).

Table 4.6 Computers connected to the LANs and the Internet

School type	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm
School	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Computers on LAN	0	12	10	0	31	21	18	30	10	10
Computers linked to the Internet	0	12	2	0	20	20	1	0	2	10

The number of computers that could access the Internet also varied from school to school as indicated in Table 4.6. Connectivity was apparently available at seven of the ten schools, S2, S3, S5, S6, S7, S9 and S10. While S2 reported 12 possible points, these were inactive points that were once in use when the school participated in the project: "This is a journey". (http://www.thisisajourney.org/partschools/partschools.asp?id=3 /). After the project terminated, the Internet service was discontinued. In general the quality of connectivity was reported to be poor (Table 4.7).

Table 4.7 Quality of Internet connection

CS assessment of:	A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10	Frequency
Dial up connection to the ISP											
very good											0
good		1			1				1		3
poor			1				1				2
very poor						1				1	2
Speed of downloading files											
very good											0
good		1							1		2
poor			1		1	1	1			1	5
very poor											0

There were two bottlenecks; first it was the dial-up to the ISP, which was poor, and second, if connected to the ISP, the bandwidth was also qualitatively poor. For example, while the Mutare route was capable of 128 Kbps, as cited in Chapter 2, and despite 56 Kbps Modems installed in the schools, connections at speeds of less than 10 Kbps were common. The CS at S3 cited this as one challenge in his effort to build web-based resources.

4.3.5 Location of computers

Computers were located mostly in computer laboratories, apart from the few in administration offices (Table 4.8). The location became important in determining who used the computers and when they did so. Only three schools had a computer installed in the Science Department. The two computers shown under classrooms for school S7 belonged to the Maths Department.

Table 4.8 Computer locations

School type School	A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10
Number of computers in computer lab	12	16	10	26	26	20	40	40	40	24
Number of computers in Admin offices	4	2	4	3	5	2	4	4	6	3
Number of computers in Head's office	1	1	1	1	1	1	0	1	1	1
Number of Computers in Science department	0	0	1	0	1	0	0	0	0	1
Number of computers in Classrooms	0	0	0	0	0	0	2	0	0	0
Total in established locations	17	19	16	30	33	23	46	45	47	29

The 16 computers reported to be in the computer laboratory (lab) at S2 were not physically present in the lab, but stored away presumably for security reasons. The school head explained that they did not have a proper room to house them.

4.3.6 Teacher access to ICTs at school and at home

Access to computers is a pre-requisite for the use of ICT in teaching and learning. Only 2 out of the 15 teachers in this group had a computer at home. This meant they had to rely heavily on the school computers. A three-tier nominal scale sliding from *never* to *always* was used to judge the teachers' access to the school computers. An analysis of the responses on this scale is given in Table 4.9.

Table 4.9 Teacher access to school computers

Access Rating	Teacher								
Always	T3	T5.2							2
Sometimes	T1.1	T1.2	T7.1	T7.2	T8				5
Never	T2.1	T2.2	T4	T5.1	T6.1	T6.2	T10.1	T10.2	8

The picture reflected in Table 4.9 illustrates that the Physics teachers' access to school computers was restricted. Only two teachers T3 and T5.2 were likely to have access to ICT when they needed it for teaching Physics. It was noted that despite being at the same school, T5.1, the other teacher at S5 registered a different sentiment, "no access" to computers. This was taken to be an indicator for the possibility of other factors limiting use of ICT for teaching. It emerged later in the focus group discussion that T5.1 was opposed to the use of ICT for teaching: "I have no motivation teaching Physics using IT" (T5.1). Figure 4.2 was devised to depict the level of access to ICT by the teachers at their respective schools.

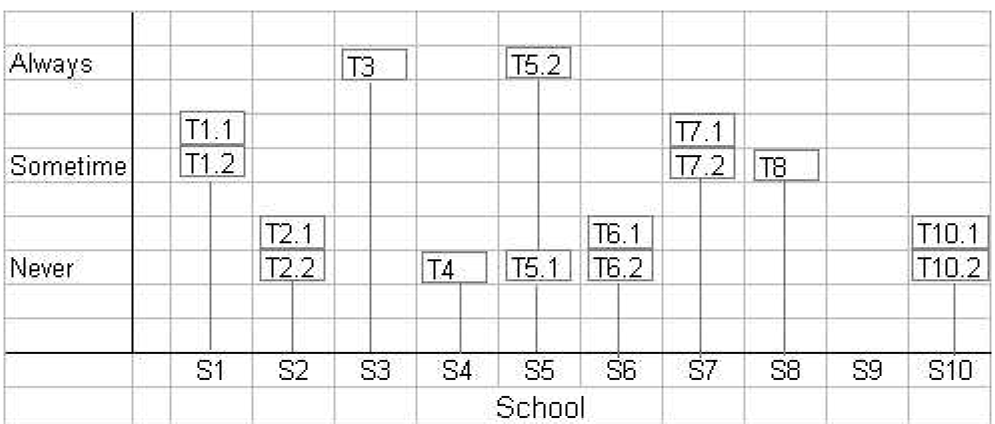


Figure 4.2 Map of Teacher- access to ICT by school

S3 and S5 were reported the most likely to allow access for use of ICT for teaching purposes. Three other schools S1, S7 and S8 were likely to sometimes allow access to computers for teaching purposes. According to the rest of teachers, five of the schools never allowed access to ICT for teaching and learning purposes.

4.3.7 Student access to ICTs at school, at home and elsewhere

A-level Physics students indicated three avenues through which they could access ICT for learning Physics: the school, home and elsewhere. Their "elsewhere" included relatives' computers, such as those belonging to the fathers' workplace, sisters' workplace, friends or the Internet café. In Table 4.10, Y and 0 mean students had access or no access respectively.

Table 4.10 Student Access to ICT at school, at home and elsewhere

		A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10	Number
School access	Often				Y	YY			Y			4
	Sometime	YY		YY	Y		YY	YY	Y	YY	YY	14
	Never		00									2
Home access	Yes			YY	Y				Y	Y	Y	6
	No	00	00		0	00	00	00	0	0	0	14
Elsewhere access	Yes	YY		Y	YY	Y		Y	YY		Y	10
	No		00	0		0	00	0		00	0	10

Four students from 3 schools indicated that they had access to school computers often. Fourteen students at 8 schools sometimes had access. Two students at one school never had access at all. It is interesting to note the emerging pattern that those who had access at school also had access elsewhere. There were six students belonging to five of the schools who were privileged to have home access to computers. The "elsewhere" (extra -school) category serviced five students at relatives' offices and another five at Internet café outlets. The twin YY or 00 also show where both students at the same school concurred.

With access to available infrastructure it was important to establish how the infrastructure is being used. The next section highlights what the schools focused on in using the ICT infrastructure.

4.4 The focus of use of ICT in the schools

The reality on the ground was that the focus of use of ICT in the schools was IT (Figure 4.3). In this category, four schools used the ICT labs for Computer Studies, three schools offered ICDL in addition, five schools used them for computer literacy and one school offered computing as an A-Level subject. This focus on IT left the gap represented by X under the learning tool category in Figure 4.3.

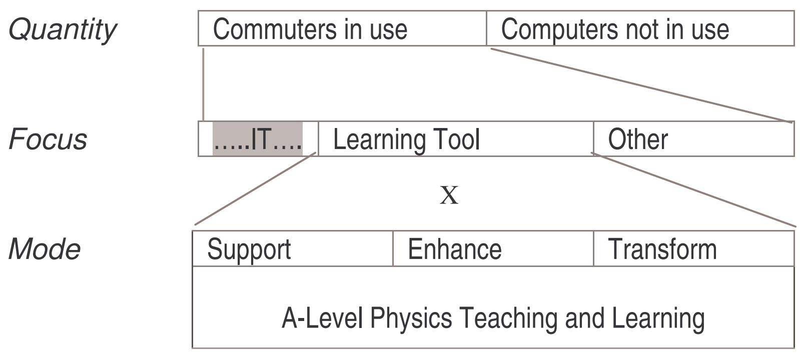


Figure 4.3 Computers ignored as learning tool

What follows is an analysis of data that would attempt to explain this gap.

4.5 Fractured Links

The preceding sections have already proved the availability of ICT mediation tools in the ten schools. In addition access to this ICT infrastructure has been described. These pieces of data are now superimposed on to the activity system representation, Figure 4.4, as a first step towards explaining the gap X identified in Figure 4.3.

Examples of the range of ICTs identified in the schools is summarized and shown at the apex of the mediation triangle (Figure 4.4). These include networks, a good range of hardware and generic software and some Physics CDs. Those essential for Physics, but not available in the schools, are indicated with x against the name.

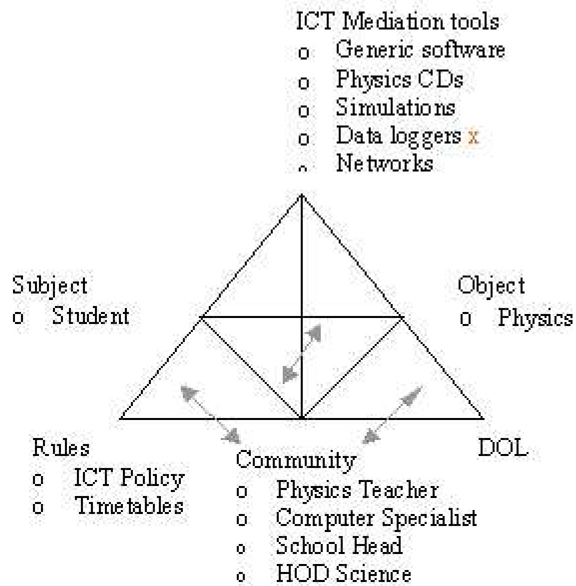


Figure 4.4 ICT Tools in schools mapped onto activity system triangle

The first thing that is glaring in the light of activity system is the [10] "fracture" in the link between the Physics teacher in the community and ICT mediation tools for teaching and learning. Despite the availability of the ICTs in all the cases studied, the Physics teachers were simply teaching without ICT. Even the syllabus stipulation such as in Syllabus 9244 advocating for use of ICT was ignored. The other fracture that occurs is the community to DOL path, which mainly deals with relations in the community and the roles of the members. The detail is covered later in sections 4.11. The third fracture occurs in the community to rules link where the absence of ICT policies was reported in all the schools.

What the teachers themselves said as key members in the community grouping is analysed next.

4.6 Opinion of teachers on use of ICT

The ZIMSEC Syllabus 9188 left out the aim enunciating the use of ICT. The opinions of the teachers were sought on this matter. Surprising enough, what surfaced was the fact that the same teachers ignoring use of ICT expressed a positive attitude towards use of ICT in teaching and learning of Physics (Table 4.11).

[10] In the current study a "fracture" is observable when an expected link (in theory) between any two entities in the activity system is dysfunctional in practice. In activity theory, Lim & Hang (2003: 52-53) refer to these as "contradictions" They go on to say these could be "internal" and external within and between activity systems."

Table 4.11 Teachers opinion on exclusion of reference to ICT in Physics syllabus 9288

Do you think this omission was a good idea?	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
Yes					1			1			2
No	2	2	1	1	1	2	2			2	13

All the teachers surveyed except for two, felt that the ZIMSEC syllabus, like the Cambridge syllabus, should have made reference to use of ICT in teaching and learning of Physics. Some of the reasons advanced by the teachers for this stance are reported in Table 4.12.

Table 4.12 Sample reasons for teachers in favour of use of ICT

- It is “a modern way of science teaching and learning”.
- Simulations can be used for concept development (take advantage of).
- Presentations (slides) make a good substitute for chalk and talk.
- Simulations make a good substitute where equipment is not available.
- Preparations for higher-level Physics and for the world of work.
- Enables conduction of individual tutorials.
- Technology push

By way of triangulation, the teachers’ views were also sought by using a series of jumbled positive and negative statements about use of ICT in their teaching. Their responses were measured on an ordinal scale of the Likert-type as in Table 4.13.

Table 4.13 Opinion statements on exclusion of ICT use in syllabus

	SD	D	N	A	SA	% Agree
The A level syllabus is fine without mention of ICT.	6	7	1	1		6
With use of ICT it is impossible to finish the syllabus.	3	4	6	1	1	13
Use of ICT for T/L is for developed countries.	7	4	1	2	1	20
Bringing ICT to the physics lab is a hassle.	2	5		5	3	53
ICT is the "in thing" for teaching /learning A-level physics.	1	1	4	8	1	60
ICT is a must for A level physics teaching and learning.	1	3	1	7	3	67
Use of ICT for physics T/L should be made compulsory		3	2	7	3	67

SD =strongly disagree D =disagree N =neutral A =agree SA =strongly agree

From the mixture of these statements the teachers' responses were sorted in order of frequency of response resulting in Figure 4.5. The statement that the A-level syllabus was fine without mention of use of ICT, polled lowest (6%) while its contrary, that use of ICT for Physics should be made compulsory, gained the top position (67 %). Figure 4.5 further shows how the rest of the statements fitted in to establish a general trend that the teachers were in favour of use of ICT. Their reasons for taking this stance are the same as captured in Table 4.12. The teachers' list shows that they were aware of some possibilities of applying ICT in their teaching.

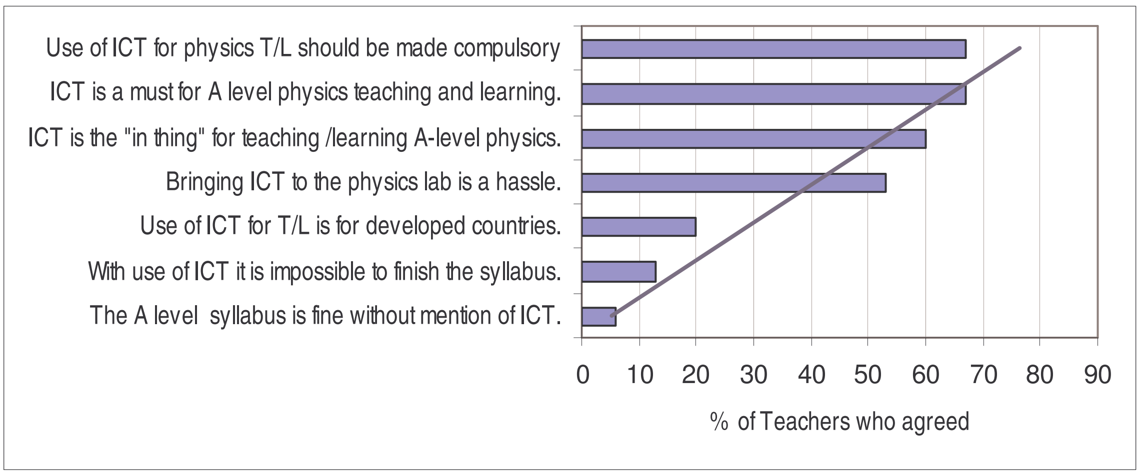


Figure 4.5 Response to opinion statements on exclusion of ICT use in syllabus

4.7 Which teachers use ICT?

Having established their views the study went on to establish which of these teachers would use ICT in their teaching. First the teachers' profiles had to be established.

4.7.1 The teacher profiles

Most teachers were aged between 30 to39. These teachers with a teaching experience of over 5 years were likely to be senior members of staff in their schools.

Table 4.14 Teachers, ages and experience

School type	A		B		Cp	Cm	Cm		Cm		Cm		Cm	Cm	Cm	
School	S1		S2		S3	S4	S5		S6		S7		S8	S9	S10	
Teacher	T1.1	T1.2	T2.1	T2.2	**T3**	T4	T5.1	**T5.2**	T6.1	**T6.2**	T7.1	**T7.2**	**T8**	T9	**T10.1**	T10.2
Age group[11]	± 25	± 35	± 25	± 35	± 35	± 35	± 35	±35	± 35	±45	± 25	±35	±35	–	± 25	± 35
Experience[12]	≈5	≈10	≈1	≈10	≈20	≈5	≈5	≈10	≈5	≈10	≈5	≈5	≈10	–	≈5	≈5

The most experienced teacher T3 was at a private school S3 and teaching the GSCE Cambridge syllabus. S3, a private school, operated with this one teacher who had teaching experience of almost 20 years. The ideal set up in the schools was to have two A-level Physics teachers, one handling Form 5 and the other Form 6. Six of the schools had the two teachers in place. At S8 the second teacher was deceased and was yet to be replaced, while at S9 the teacher left for greener pastures. The Physics teacher at the neighbouring school helped with lessons once in a while. The Chemistry teacher was asked to look after the classes in the mean time, but indicated that he was not qualified enough to complete the questionnaire.

Of the fifteen teachers, only six reported having used ICT for purposes of Physics teaching. This is marked Y in Table 4.15.

Table 4.15 A-level teachers per school and their use of ICT

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm	
School	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
Teachers	2	2	1	1	2	2	2	1	0	2	15
Use ICT	00	00	Y	0	0Y	0Y	Y0	Y		Y0	6

The non-users are indicated with 0. It is interesting to note that in four schools (S5, S6, S7 and S10) the teachers at the same school indicated Y and 0. This suggests that it is not necessarily the availability or lack of ICT infrastructure at each school that defines teachers' use of ICT. The next section discusses the nature and extent of the reported use.

[11] ± means actual age is within 5 years below or above table value.
[12] ≈ means approximately

4.8 Extent of use of ICT

4.8.1 Nature of reported use by Physics teachers

The reported use of ICT by the 8 of the 15 Physics teachers is given in Table 4.16. Seven of the teachers reported non-use.

Table 4.16 Physics Teachers' uses of computers

Use	Teacher					
Typing notes in *MS-Word*	T3		T6.2			T10.2
Typing tests and exams						T10.2
CD: accessing past exam papers	T3			T7.2		
CD: Encarta Reference 2003		T5.2				
Internet: downloading and printing notes				T7.1		T10.1
Simulation: demonstrating phenomenon	T3			T7.2		
Doubtful use					T8?	

Although the teachers included typing, this was done once in a while since the schools had facilities and personnel for this purpose in administration. The three teachers T3, T6.2 and T10.2 emphasized producing notes, which were in turn printed for students. When the opportunity arose for T10.1 to get access to the Internet, he downloaded notes and also printed them for students. When T7.1 accessed the Internet he would look for Cambridge past examination papers. T3 and T7.2 also took advantage of CDs from Cambridge University that include past examination papers and examiners reports on these papers.

For T3 there was a Science department computer, which according to him could be used in teaching, for example running simulations for experiments that were not possible in the Physics laboratory. However this had not happened and the students made no report of such use.

The Encarta CD, to which T5.2 made reference, is a large repository of information. It was however used in a very traditional manner where according to T5.2, *"students obtained notes from the Encarta reference dictionary"*, assuming they learnt in the process. Such use was not planned into T5.2's lessons. The warning signal here is that as ICT finds its way into teaching and learning, it could be used to perpetuate the same traditional methods that have perverted science teaching and learning in the past.

One teacher, T7.2 reported use of simulations to demonstrate Physics phenomena. The student, S7.2 confirmed having *"listened to CDs on quantum physics"*. This student who reported, "*It was easier to understand the concepts when a computer was used",* appreciated the combination of video and sound on the Multi-media computer system. However the computer specialist, the teacher and the student concur that this was rarely done.

T8 was knowledgeable on ICT and hinted during the informal interview that his project at college was on *use of computers in teaching*. He indicated in the self-reporting questionnaire having used some simulations the previous year. His current students reported no use of ICT. He clearly did not practice what he knew.

4.8.2 Extent of use of spreadsheet programs

MS-Excel, or a similar spreadsheet program, can be such a useful tool with so much potential in Physics teaching and learning and therefore section 9 of the questionnaire was devoted to it. When the teachers were asked what spreadsheet functions they used, only two teachers were likely to use spreadsheet functions once or twice in the term for one or more of tasks such as carrying out calculations, drawing graphs, what-if functions, or modeling Physics concepts. Nine out of the fifteen teachers never used spreadsheets. Worse still, this tool was completely unknown to three of the teachers. When asked to rate their own skills the following results were obtained.

Table 4.17 Spreadsheet skills[13] for Physics teachers

Rating	Teacher					Number
Expert	T5.2	T8	T10.1			3
Confident	T1.1	T1.2	T2.1	T2.2	T6.2	5
Beginner	T3	T7.1	T7.2	T10.2		4
Zero	T4	T5.1	T6.1			3

[13] Expert: can teach others. Confident: able to do tasks without help. Beginner: manages tasks with help.

Teacher T5.2 was seconded to the computer department and helped the CS in the teaching of the computer literacy course in the school. This could be the reason why he rated himself very highly. When it came to use of ICT in teaching and learning of his subject Physics, his rating hovered between the *sometime* to *never* categories. Once or twice in the term he would use spreadsheet formulae and graph function in general, but he would never go on to use it for Physics in applications such as in laborious calculations or graphing data in practical experiments.

T8 also rated himself as an expert. Although he did a project on computers in teaching during his teacher training, his knowledge did not translate into practice in this case. Like the other teacher (T5.2), both his students indicated they never used ICT in class. He in turn did not know what ICT skills the students possessed.

The skills that teachers reported to have were mapped to the level of use in Figure 4.6.

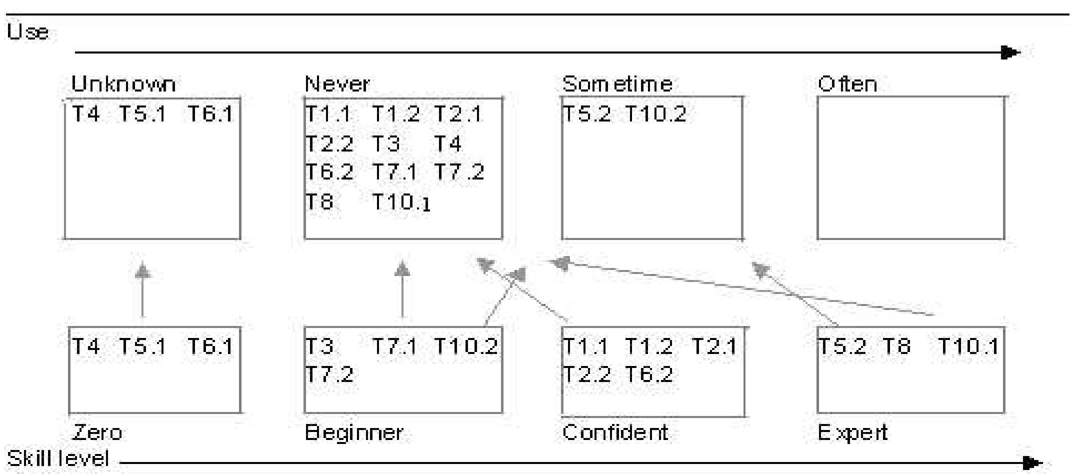


Figure 4.6 Mapping teachers' *Spreadsheet* skills to use by the teachers

Note: Sometimes was explained to mean once or twice in the term. Often meant use as a handy tool in the day-to-day teaching and learning of Physics.

Spreadsheets were unknown to three of the teachers. The zero-skills group occurred at schools S4, S5 and S6. This is despite the presence of the latest computers running *MS-Office 2000* at S4 and a computer in the Science Departments at S5. There clearly are other factors apart from mere presence of appropriate infrastructure. The teachers who rated themselves beginners, confident or expert did not go ahead to demonstrate use of the skills either. They were therefore bunched in the *never use* category.

4.8.3 Extent of use of the Internet

None of the Physics teachers used the Internet often. Only 6 out of the 15 (40%) of the teachers reported sometimes using the Internet; the other 9 (60%) just never used it (Table 4.18).

Table 4.18 Extent of use of Internet by teachers and students

	A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10	Total
Often											0
Sometimes		T2.1	T3	S4.1		T6.2	T7.1			T10.1 T10.2	6
Never	T1.1 T1.2	T2.2		T4	T5.1 T5.2	T6.1	T7.2	T8			9

The main reasons given by those who never used the Internet were:

- Unavailability of a connection as stated by the 2 teachers at S1
- Inaccessibility of connected computers as stated by the teachers at S4, S5, S6 and S7.

Even those teachers, who reported that they sometimes used the Internet, rarely used it for purposes of teaching and learning of Physics. T2.1, a young teacher reported sometimes conducting general searches. This was done elsewhere since the school Internet at S2 was disconnected. T3 resorted to the Internet when the textbook failed and he gave an example of "cell phone technology that is in the new Cambridge Syllabus 9207." [14] The Internet was then seen as a source of information that the teacher could not necessarily obtain in the traditional sources such as textbooks. This information when collected would be typed and handed to the students. Alternatively the students would simply be told. This seems to strengthen the traditional teacher role – that of being the source of knowledge. The use of Internet reported by T6.2, T7.1 and T10.1 was very general, falling short of innovative ways that were possible with such a facility. For example T6.2 indicated that he downloaded "relevant documents" which were

[14] This syllabus replaced 9244 of 2000.

not specified. Likewise T10.1 broadly mentioned doing “research” on the Internet. T7.1 searched for Cambridge examinations.

Although the computer specialist at school S5 reported that teachers could book the computer laboratory for educational searches with their students, Physics teachers at this school did not take advantage of the facility. Also of interest was school S4 where S4.1, a student went ahead of the teacher and used the Internet after school hours. This is discussed later under the extra-school use of ICT.

4.8.4 Extent of use of CDs and Simulations

Only 4 out of 15 (26%) of the teachers indicated that they had used 'A' level Physics CDs (Table 4.19).

Table 4:19 Teacher use of CDs & simulations

School type	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm	
School	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Total
CD			T3				T7.1, 2	T8			4
Simulation		T1.1		S4.1							1

These CDs were limited to the GCSE 'A' level Physics CD, and the Encarta electronic library. This is explained by the fact that these were the ones available in their schools. T1.1 mentioned use of simulations, but his students did not confirm this. Therefore it would seem that Physics teachers at these schools seldom planned use of ICT into their lessons.

The next section takes a look at the students’ experiences.

4.9 Student use of ICT for learning Physics

A-level Physics classes were notably small; at a glance Table 4:20 shows that the most common class size is a total of 13 students. Boys outnumbered girls. Except for girls' schools, by simply inspecting the figures the most common number of girls in a Physics class is 2 or 3. However it should be noted that more girls took up A-level Physics in an all girl's school than in co-educational school. Why this is so remains a subject for investigation.

Table 4.20 A-Level Physics class size per school

	School	A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10
Form 5	Boys	13	11	10	24	11	17	14	12	15	gs
	Girls	bs	2	3	3	2	1	0	0	1	9
	Total	13	13	13	27	13	18	14	12	16	9
Form 6	Boys	15	17	11	13	9	19	13	16	10	gs
	Girls	bs	3	2	3	0	2	0	0	0	6
	Total	15	20	13	16	9	21	13	16	10	6

Note: bs depicts boys' only school, gs indicates girls' only school

On average 12 of the 20 students reported that they were confident or experts with their IT skills (Table 4.21). Thus A-level Physics students brought with them a repertoire of ICT skills from the lower forms. This is a strength that could be exploited. What they need at this level is the availability of ICT to apply their skills especially in the learning of Physics.

Table 4.21 Students Level of Computer Skills[15]

Core skills	Nil	Beginner	Confident	Expert
Core skills	1	2	9	8
Word Processing	2	5	7	6
Graphics /Drawing	3	6	6	5
Spreadsheet	2	6	4	8
Multimedia	5	5	5	5
Internet	3	6	6	5
Average	**3**	**5**	**6**	**6**

[15] Beginner: manages tasks with help. Confident: able to do tasks without help. Expert: can teach others.

The distribution of students' skills in Table 4.21 is illustrated in Figure 4.7 to make the picture clearer.

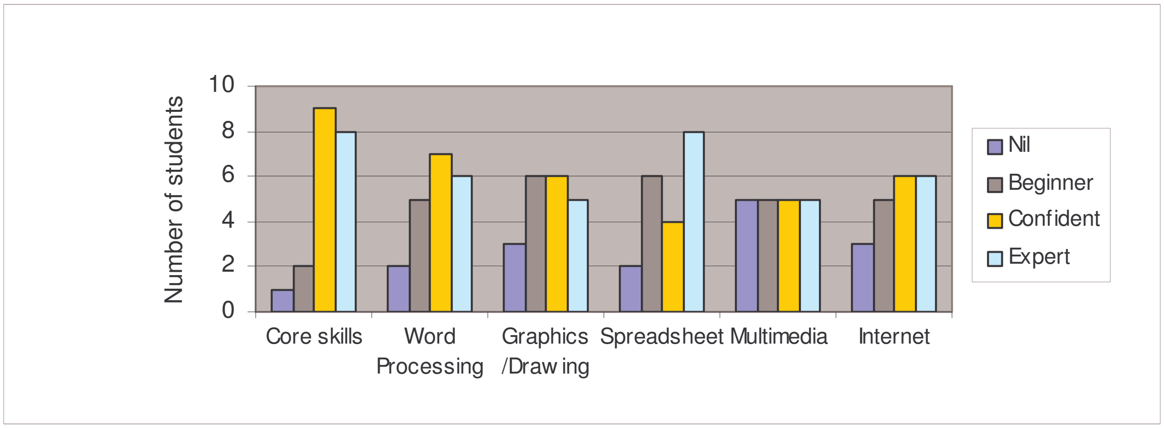


Figure 4.7 Student ICT skills level

Core skills included the use of the mouse and keyboard and general navigation within a *Windows* environment; most students were confident (Figure 4.7). In Graphics the students indicated an ability to draw a diagram such an electric circuit in *MS-Word* and in *Paint.* The spreadsheet section considered data entry, use of formulas and creation of graphs. Multimedia focused the students' attention on use of CDs. There was an even distribution of students across the categories ranging from no skills to those claiming expertise. On the use of Internet, the confident and expert category attracted six students each. These six students were able to send and receive e-mail as well as browse the Internet. Very few students indicated nil skills in the given categories. The majority of the students expressed that they were confident and experts as far as the given ICT skills were concerned, which was expected considering that they underwent training in various ICT courses (Table 4.22).

Table 4.22 Computer Courses done by Students

Course done	Students	Number
ICDL	S5.2	1
Computer Literacy at school	S1.2 S2.1 S2.2 S3.1 S3.2 S4.1 S4.2 S5.1 S5.2 S6.1 S7.1 S7.2	17
Computer Studies at O-level	S6.1 S6.2	2
Computer Science	S8.1	1
Computer Literacy at home	S4.1	1

When examining Table 4.22, it appears that only two students, S1.1 and S10.1 (missing from the list) did not have a computer training background, meaning that 90% of the students were trained. The next section is an analysis of the extent to which the students used these skills in the learning of Physics.

4.9.1 Student frequency of use of ICT for learning Physics

Ten key areas of computer uses in Physics learning were listed and students were to indicate how often they used ICT in that manner (Table 4.23). They were also given the option to indicate, "*don't know*" for the ICT artefacts that they did not know.

Table 4.23 Student frequency of use of ICT for Physics tasks

	don't know	never	sometime	often [16]
MS-Excel for processing data in practical experiment	5	14	0	1
A CD for learning Physics	3	10	3	4
A Physics practical simulation on a computer	6	14	1	0
Simulation of a phenomenon in Physics	5	10	5	0
A computer tutorial program on Physics	4	12	3	1
Physics related calculations in *MS-Excel*	4	13	3	0
Drawing Physics graphs in *MS-Excel*	5	16	0	0
Internet search for Physics eg using *Google*	3	9	6	2
Physics chat on the Internet	3	16	1	2
Physics DVD	3	14	2	1
Approximate Average	**4**	**12**	**3**	**1**

[16] Often: more than once every week, sometime: once or twice in a school term

From the students' responses to questions about their uses of ICT in learning, what emerged was that most students never used the given ICTs for Physics learning purposes. A number of these applications were also unknown to them. Inspecting Table 4.23 shows that top on the range of unknown applications was the use of simulations followed by the use of *MS-Excel.* All except one student also never used the spreadsheet software *MS-Excel.* Combining all the ten applications together, students who sometimes and often used the given ICT artefacts were on average only 4 out of 20 which represents 20% of the participants.

The next section is an analysis of data that might account for the emerging pattern of the use of ICT by the A-level Physics students.

4.9.2 Student access to ICTs

An important factor that determines use of ICT is access to facilities. As has been detailed in section 4.3.7, Physics students' access to ICTs was three-fold: at school, at home and elsewhere. The number of A-level Physics students with regular access to the school ICT infrastructure was small with only 2 out of 20 students indicating that they 'often' had access to computers at school (Figure 4.9).

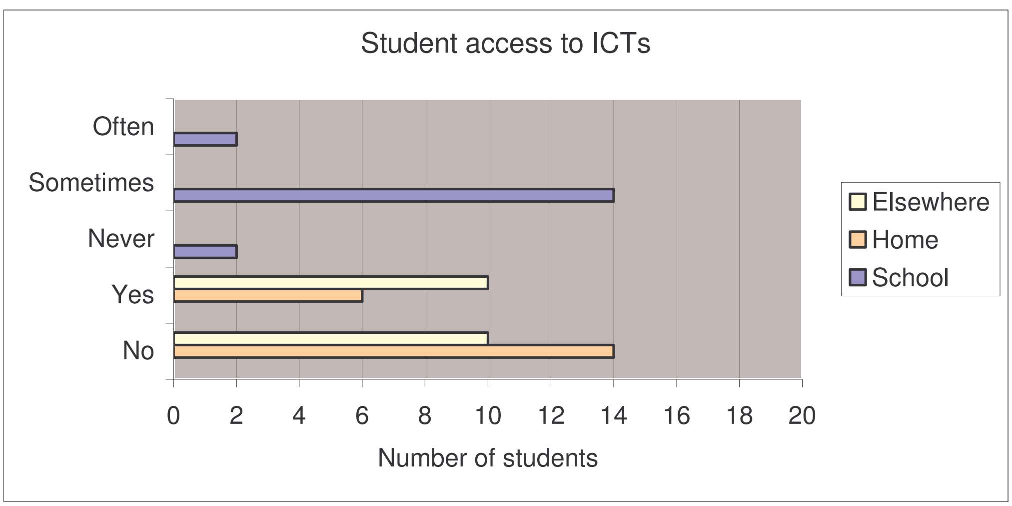


Figure 4.9 Levels of ICT access by Physics students

Although access to school computers by A-level Physics students was limited, there were ten of the twenty students who indicated 'yes' to the question on access to ICTs elsewhere while six of them had access to computers at home (Figure 4.9). The significance of this extra-school access is further described in the next section.

4.9.3 Students use of extra-school computers

Students used the extra-school ICT opportunities variously. Their miscellaneous list of what they did on these computers did not include learning Physics specifically. Table 4.24 is a synthesised summary of the data from students' reports on what they did on home computers.

Table 4.24 Home computers student activities

School assignments	[2]	CD recording	[1]
Internet	[3]	Word processing	[2]
Music	[2]	E-mail	[1]
Games	[2]		

Examples of what students said they exactly did on the home computers are shown in Table 4.25.

Table 4.25 Home computers student activities: students' words

S3.1: Research for school assignments, music, internet,
S3.2: Listen to music, record CDs, search the internet, Research for the information that I need.
S4.1: Since the home computer has no access to Internet I normally spend my time on Ms word
S8.1: I normally play games, use word processors especially *MS word*, explorer, MS Access
S9.2: Playing games, Typing assignments,
S10.1: At an internet café, , , , , , , , , , , , ,
S10.2: Checking mails on the internet and downloading journals, , , , , ,

These statements by the students are void of any reference to the learning of Physics. When probed further on whether they used computers to learn Physics outside class times, 13 students said they never did, 6 did sometimes and 1 did often (Table 4.26.)

Table 4:26 Student Use of extra-school ICT

School		A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10	Number
ICT Use	Often				Y							1
	Sometime			YY	Y	YY				Y		6
	Never	00	00				00	00	00	0	00	13

The symbols Y and 0 stand for use and non-use respectively.

Out of the seven students who used ICT for learning Physics; three of them (S2.2, S3.1 and S3.2) were searching for past exam papers, one student (S4.1) said he used the Internet "for Physics topics seeking understanding". Student 4.2 who had access at the father's work, reported use of some Physics simulations. Overall one can therefore say there was restricted access to school ICTs by A-level Physics students and there were isolated cases of extra-school ICT use by some of the students.

4.10 Limitations to use of ICT by Physics teachers

The data analysed so far reveals a very low level of use of ICT by the Physics teachers and students. Only a small number of them made use of ICT, but in an irregular and inconsequential way considering the potential of ICT in teaching and learning of Physics as highlighted in the literature review in Chapter 2. This section analyses the data in an attempt to explain this paucity of use of ICT.

4.10.1 Access Constrictions to ICT for Teaching and Learning

There were various reasons given by teachers for restricted access to ICT for teaching. Three categories were derived from what the teachers said (Table. 4.27).

Table 4.27 Factors constraining access to of school ICT

Factor	School		
Administration	S2	S10	
Absence of School ICT Policy	S4	S5	S10
Monopoly by Computer Studies	S1	S6	S10

The first category identifies school administration as a power unwilling to make computers in the school available for use. “The authorities are reluctant to release *their* computers to be used in classes” (T2.1). The teachers saw the computers as belonging to the administration. In addition, according to T10, school administration lacked awareness and knowledge of the use of ICT in teaching and learning. “I strongly feel that, they (Administration) have to visit other schools and institutions for induction”. This meant that such an administration was unlikely to make policies purposing use of ICT in teaching.

The second category follows up the lack of school ICT policies that would spell out resource allocation such as time scheduling of computer laboratories and access rules. According to T4, there were no special time slots allocated to the A-Level Physics teacher and students to gain access to computers. To this T5.1 raised the same issue that “students’ access to computers occurred during other times NOT during lessons.”

The third category highlights the monopoly of ICT by Computer Studies teachers. This was raised by T6.2, T10.1, 2. “The computer lab is only available for computer lessons” (T6.2). The set up in the schools was to assign computers to a computer lab designated to a computer-related subject such as Computer Studies or computing or related computer courses taught by a specialist teacher. Therefore to everyone else, the computers belonged to a subject area and the specialist teacher. This scenario, though highlighted by these three teachers, was observed to cut across all the 10 cases.

4.10.2 Under-utilisation of ICT infrastructure

In some schools monopoly of the ICT infrastructure by computer teachers led to its underutilisation. As an example the reality on the ground included Computer Studies at S1 with 6 double periods of 80 minutes each, which would use 8 hours per week. On average this comes to only 1.6 hours per day during which the computer lab is occupied. Another scenario was at S9 where A-Level computing as a subject had 2 students only who used a lab with 24 computers. The third scenario was a top level management issue where 25 computers were locked away with one released for typing a test or exam once in a while (S2). It was also noted that the local area networks at S2, S4, and S9 were incomplete or out of use. In cases where the networks were up and running, not all of them were fully utilised. It was only at S3 and S5 that some resources such as printers and folders with learning material and the Internet were shared on the network. Only in one case (S3) was Physics resource material found on the LAN (though beyond the level of A-Level Physics).

It was interesting to note that with the small number of Physics classes, of less than 20 students on average, it was possible to achieve a student to computer ratio 1:1 for the Physics classes. There is a big gap between what is available and use of the same for teaching and learning.

4.10.3 Awareness

The Physics teachers were not sufficiently aware of the potential of ICT in the teaching and learning of their subject. Table 4.28 shows the ICT artefacts that were indicated by a number of teachers (number in brackets) as not available or unknown to them.

Table 4.28 ICT artefacts not available in schools or unknown to teachers

Not Available	Laptop	[10]	Data loggers	[7]	Flash memory	[8]
	Beamer	[9]	CD-writer	[4]	E-mail	[5]
	Scanner	[7]	CD-ROM	[4]		
Unknown	Data loggers	[3]	CD-ROM	[1]	*MS-PowerPoint*	[1]
	Scanner	[2]	CD-writer	[1]	*Paint*	[4]
	Beamer	[2]			Flash memory	[2]

The list provided to the teachers for them to indicate the extent of use by them in teaching included groups of basic ICT artefacts such as data capturing devices, storage devices, multimedia tools, some generic software and Internet components. In the case of CD-ROM, CD-Writer, *MS-PowerPoint* and *Paint*, some teachers reported these as not available, contrary to the CS report and the observation notes. This could only be an indicator of their lack of knowledge and awareness of the artefacts. Considering the ICT tools that the teachers reported as unknown, it was most unlikely that teachers would plan these into their lessons. A surprising response came from T4 who denied knowledge of all the artefacts in the list including the most common. This was despite the fact that his school, S4, had state-of-the-art-computers.

4.10.4 Teacher Competencies

In terms of training, 12 out of 15 teachers obtained their ICT skills at University or College as part of their qualification. Seven of them had gone further to acquire more skills auto-didactically.

Five key areas were chosen for teachers to report on the skills they possessed and those they used in teaching Physics. This self-appraisal was a sliding scale carrying the meaning: (0) they did not have the skill; (1) Beginner - they could manage but with some help; (2) Confident - they were able; (3) Expert - they were proficient, or very capable.

Eight of the teachers were confident with their word processing with one acknowledging lack of the skills. The rest were either beginners or experts (Table 4.29).

Table 4.29 Teachers' skills level rating[17]

	Nil	Beginner	Confident	Expert	Use
Word processing	1	2	8	4	1
Core skills	3	3	4	5	1
Graphics	4	5	3	3	none
Internet	5	3	4	7	2
Presentation	5	2	4	4	2

On core skills, which included file management in a *Windows* environment and connecting peripheral devices to a computer system, the teachers' skills ranged from nil (3) to Experts (5). Overall skills on graphics were not common despite the fact that these were necessary when it came to drawing of Physics' diagrams; scanning, importing and modifying images. The overall

[17] Beginner: manages tasks with help. Confident: able to do tasks without help. Expert: can teach others.

impression of teachers' reported competence level for this group is further illustrated in Figure 4.10.

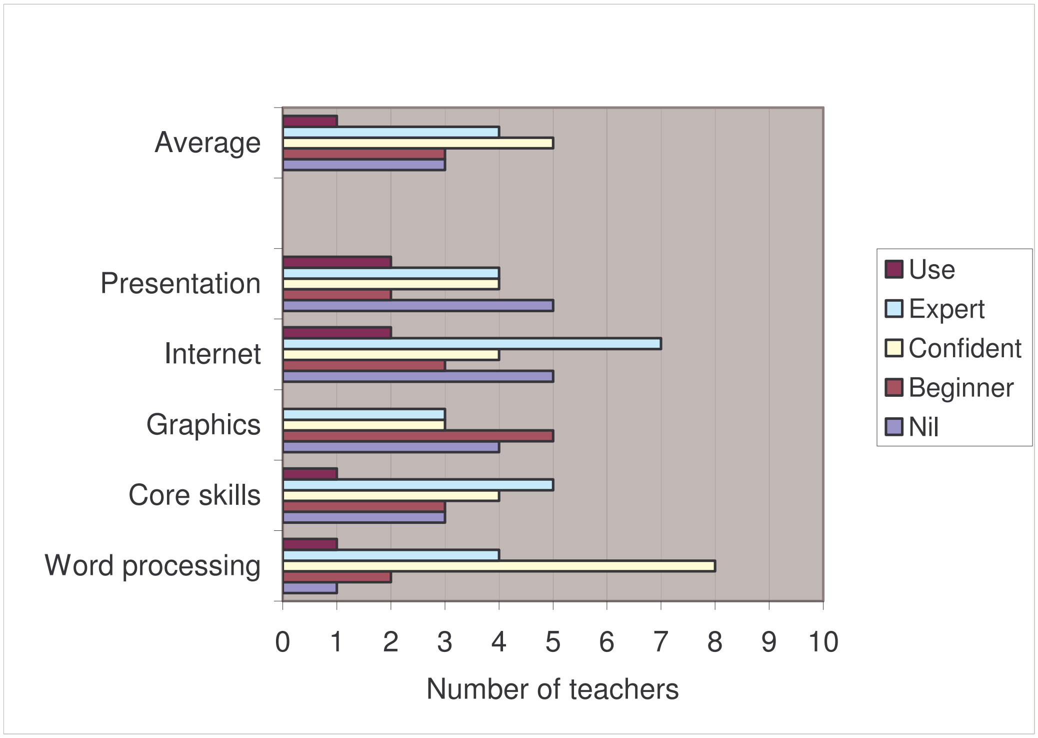


Figure 4.10 Teacher ICT Competence Level

Presentation skills such as slide show preparation in *MS-PowerPoint* were absent in five of the teachers. Internet skills were most common with seven of the teachers indicating that they were experts.

This skills position was cross checked with a narrower scale which required the teachers to rate themselves on use of ICT skills they had; first for themselves in general and secondly for teaching of A-Level Physics (Table 4.30).

Table 4.30 Teachers self-rating on use of skills

	Beginner	Confident	Expert
Rating on general use of skills for self	3	8	4
Rating on use of skills for teaching Physics	5	7	2
Moderated rating	14	0	0

The majority of the teachers (8) claimed confidence in the general use of skills they had. Three said they were beginners, (would manage with help), while 4 claimed expertise.

Coming to the use of their ICT skills in teaching Physics, 5 of the teachers acknowledged being beginners, while 7 maintained that they were confident users and claimed they were experts. One abstained from polling.

In Table 4.31, a beginner (B) refers to a teacher who could manage to use ICT with help; confident (C), refers to a teacher who was able to use ICT for teaching; and expert (E) refers to a teacher who claimed to be proficient in the use of ICT for teaching.

Table 4:31 Teacher self assessment of ICT skills level

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Rating for self	EC	CC	C	B	CE	BC	BC	E		EC
Rating for teaching	CC	CC	C	B	- E	BB	BC	E		CB

Of interest are schools S5 and S8 where teachers T5.2 and T8 respectively claimed to have expertise in both their ability to use ICT for self and for the teaching of Physics. This contradicted the data from the observation during site visits and interviews with the teachers, when such expertise in the use of ICT in teaching of Physics was not evident. The claim was also negated by the data from the student who reported that her teacher had never used ICT (S8.1). When student S5.2 pointed to the use of ICT, it was only with reference to an Encarta reference CD and this could not be a basis for claiming expertise by the teacher.

On the basis of the other sources of data, observation, interviews and student questionnaire, the teachers' self-assessment of ability to use ICT for teaching was moderated as reflected in Table 4.32.

Table 4.32 Teachers' Moderated assessment of ICT skills Level

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Ability to use ICT for self	EC	CC	C	B	CE	BC	BC	E		EC
Ability to use ICT for teaching	CC	CC	C	B	- E	BB	BC	E		CB
Ability to use ICT for teaching *moderated*	BB	BB	B	B	- B	BB	BB	B		BB

The moderated value placed all the teachers at the beginners' level as far as use of ICT for teaching Physics was concerned. This level recognised the potential in the teachers and who with some help and scaffolding would be able to move to the next level of confidence.

4.11 Division of labour (DOL)

4.11.1 Teacher – Computer specialist collaboration

The link between the Physics teacher and the computer specialist was 'fractured'. In the ten cases studied five computer specialists acknowledged having given help to the Physics teacher concerning ICT as used in teaching of Physics. The other four denied having rendered any such help (Table 4.33). Thus although a teacher at S4 indicated in the questionnaire that he needed assistance with basic computer skills, he was unlikely to get such support from the CS.

Table 4.33 Physics Teacher-CS DOL

School type School	A S1	B S2	Cp S3	Cm S4	Cm S5	Cm S6	Cm S7	Cm S8	Cm S9	Cm S10	
Help given			CS3		CS5	CS6	CS7	CS8			5
No Help at all	CS1	CS2		CS4						CS10	4

Where some interaction between the Physics teacher and the CS occurred, the nature and extent of help seemed scanty and inconsistent. Table 4.34 captures how the five computer specialists described their collaborative efforts.

Table 4.34 Nature and frequency of CS help to Physics teacher

	Nature of Collaboration	Frequency
CS3	Advised teacher on capabilities and potential of computers as a teaching aid	Not more than 3 incidents
CS5	End user assistance	Rarely/ irregularly
CS6	Using CDs	Rarely/ once
CS7	Using CDs on Physics to teach the subject	Rarely
CS8	Information browsing on the net	Not often

One reason for the lack of sufficient collaboration could be the position accorded the CS in the schools. The computer specialists in the schools were engaged as computer teachers first and foremost and therefore play their role like any other teacher in the school. During the visits CS1, CS2, CS5, CS9 for example were found busy marking tests or assignments. CS6 and CS10 were found conducting lessons.

Some observable implications of lack of collaboration

The CS at S8 had a useful collection of Physics CDs that included GSCE key stage 4 Physics, GSCE Physics series covering force, motion, optics, matter, earth, stars and also electricity and magnetism. However the Physics teacher at the school never mentioned these and neither did his students. They did not seem to be aware of the availability of such a resource. This reflected a *fracture* in the community's DOL, referred to earlier in Figure 4.4 in section 4.5. In this case the fracture manifests in the lack of collaboration among the members namely the CS and the Physics teacher.

In a similar situation Form 6 students at S9 mentioned having used a CD on electricity and magnetism with the teacher who left. The CS at S9 understood there were some Physics CDs at the school, but had never bothered to locate these. He suspected these were handed over to the school secretary. The same applied to the CS at S7 who remembered there were Physics CDs that came with one donation of computers. The Physics teachers did not highlight these either. It was also emerged that the computer specialists at S3 and S9 did not know what Physics CDs were available in their schools. The implication is that such resources would not find their way on to the school LAN, even if licensing agreements permitted this.

4.11.2 CS Support Role in DOL

One example of good practice was a local initiative by the computer specialist at S3 to establish an intranet with various subject portals. This was called the S3 Research Network, built on Web Technology. Each subject portal was an accumulation of downloads from the Internet, which could be viewed off-line. At the time of the site visit, he was found busy on the server. However in his effort to establish subject portals, CS3 met the frustration of subject teachers failing to come forward with input as specialists in their subject areas. On inspecting the Physics portal it was observed that this high school portal ended up with material equivalent to final year University Physics on Physical optics. This could scare off any A-Level visitor to such a web page. Collaboration between the A-Level Physics teacher and the CS would have solved this problem.

Another good example on the DOL was seen at S5 where the computer specialist had the CD Encarta 2003 shared on the network. Students from various subjects, Physics included, browsed through the CD with little supervision even though they had elementary IT skills.

4.11.3 Teacher-Teacher Collaboration

The absence of Teacher-Teacher -collaboration emerged during a focus group discussion at S5. One Physics teacher (T5.1) was not aware of the availability of CDs in the school, which the other teacher (T5.2) and some students had used.

4.12 What is changing?

The advent of ICT in the schools studied is yet to make an impact on the way teachers teach and students learn Physics. There was very little observable change in the Physics teaching and learning ambience. One student commented:

> We have not recognised any difference (learning Physics with computers and when computers are not used) since our teachers do not use computers to teach Physics (S2.1).

This sounded like a dead end, at a school where computers were available but locked away. At such a school it was Physics lessons as usual, with teachers holding to their familiar ways of teaching Physics. Tradition was the order of the day.

4.12.1 Student Motivation

Elsewhere three students recalled some occasions when a computer was used, Table 4.35.

Table 4.35 What's different when ICT is used? Students said:

S5.2	The lesson becomes more exciting as we (students) view and get information directly; the lesson becomes short and precise.
S7.2	It is easier to understand concepts when a computer is used
S9.2	When using a computer one visualizes what really will be taking place in real life unlike in classroom lectures where no simulations can be observed.

The sentiments raised by student S5.2, highlights pedagogical issues. One could pick on the aspect of motivation, where the student got excited. Traditionally the Physics teachers would tend to use the lecture method as highlighted by student S9.2. For students the lectures tend to be long and boring as implied in S5.2's comment. Use of ICT would have the potential to make a difference and encourage independent learning.

4.12.2 Student Role as Independent learner

> I usually use it (computer) when studying forces in beams from a program I have and … to visualise what an atom looks like when all the cells are in place (S4.2).

The excerpt from this student's response highlights a major change that ICT is likely to bring in the learning of Physics. No longer will learning be confined to Physics laboratories in the schools. This student had a CD at home with simulations and visualisations. Thus while at home the student could simulate experiments and learn independently.

Table 4.36 Independent student learning

S4.1 Since the home computer has no access to Internet, I normally spend my time on *MS-Word.* I do most of my research on the Internet cafes' since I find it easy to understand Physics on websites. Yes, I have an email address and have used it to communicate about Physics with a friend of mine and my father, who is in the United Kingdom. My mother is very influential in encouraging me to use the computer for Physics and she is the one who guides me.

This transcript from student S4.1 brought to light how ICT was likely to change the Physics learning environment. ICT took the learning of Physics to the Internet café. In other words ICT was capable of creating a Physics learning environment wherever there was a connection to the Internet, even away from the conventional Physics laboratory. ICT also opened a channel of communicating about learning Physics. Electronic mail could change the learning environment. The sociometry (patterns of association) in the learning environment changed. The student could choose with whom to discuss Physics matters, over and above the usual 10 – 20 students in the Physics class.

4.12.3 Learning of Physics concepts

Students claimed that their understanding of Physics concepts and phenomenon was enhanced when ICT was used. Both students (S4.1, S7.2) testified how ICT made their learning of Physics concepts easier.

4.12.4 Real life learning

ICT provided a platform for involving the father, the mother and a friend in the Physics learning process (Table 4.36). This sounds like the interactions in real life problem solving situations. Thus ICT facilitated in making learning a real life undertaking. If time had permitted it would have been a more enlightening to probe into the actual content of S4.1's email communication. It is however clear the mother was there to provide motivational support.

One cannot help asking the question: *where is the Physics teacher in all this?*

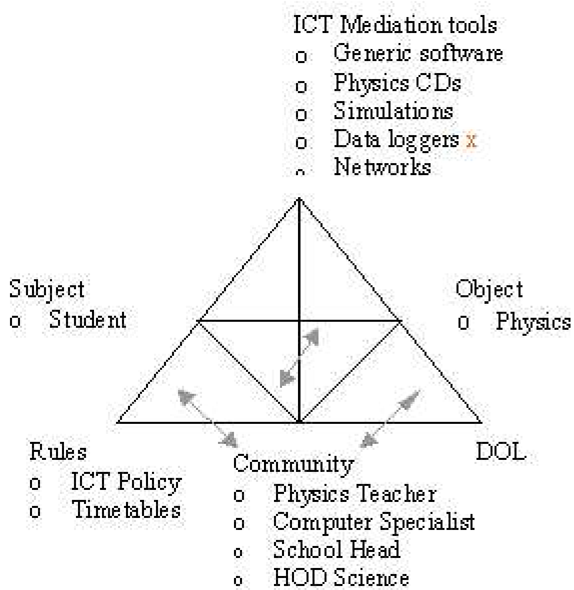
4.12.5 Teachers' Role affected

While the teacher T4 bemoaned access problems, timetabling hitches and envisaged lack of support from the CS, both his students (S4.1 and S4.2) reported extra-school use of ICT to learn Physics. In this case, the advent of ICT in the community surpassed the teachers' choice to remain traditional. Although T4's report indicated that he had never used ICT in Physics and denied any knowledge of ICT artefacts, "I have not used a computer in any of my lessons" (T4*)*, his students did*.* The use of ICT after class by students is one "driver" that could put pressure on the teacher who may not be able to ignore use of ICT for long.

Not only did the use of ICT dethrone the Physics lab as the only place where students could learn Physics, but the teacher could also be dethroned as the sole provider and source of knowledge.

4.13 Summary

In this chapter matrices, maps and charts were used to visually represent the data. Figure 4.4 is re-visited as it helps to provide a picture of the overall ICT situation in the schools.



ICTs common in the schools were mapped at the apex of the triangle.

- Networks encompassing various hardware devices including computers with processor speeds exceeding 1000 MHz, RAM greater than 64 MB and hard drive capacity of 40 GB were common.

- Generic application software mainly *Microsoft* products were also available.
- Educational CDs were less common and limited to the *Encarta 2003* CD and a few on selected topics in Physics
- Noticeably absent at all the schools were data loggers and related *Microcomputer Based Laboratory* ICTs.
- Connectivity was generally poor.

In all the schools, with reference to ICT activity system, the following links were 'fractured':

- Physics teacher – ICT mediation tool link
- Physics teacher-DOL link within the community
- Community – Rules link was characterised by absence of ICT policies and timetables.

The following findings also surfaced in this chapter (not taken in any order):

- Physics reachers notionally liked the idea of using ICT for teaching Physics, but did not seem to take steps towards the practice of using the technologies available.
- Administration, lack of ICT policy and monopoly by Computer Studies teachers emerged as some of the factors constraining use of ICT by Physics teachers.
- A-level Physics students have prerequisite skills and knowledge from lower forms but are largely unused.
- Only 25% of the students and 14 % of the teachers had access to a computer at home. Some students were beginning to have access to extra-school computers,of which 50 % of the students with access to ICTs elsewhere made up this group.
- There was evidence that this cohort of A-level Physics students included "some three students" who used extra-school computers more than the school computers for learning Physics.

The next chapter draws from these and other findings to answer the research questions.

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Chapter 5

Conclusion

> You may have the best computer, the most sophisticated curriculum software, and the fastest Internet connection … but if the teacher doesn't know how to use any of that, it is not going improve education (Rivero, 1999:54 as in Valdez et al, n.d.: 24).

5.1 Introduction

This study set out to document the extent to which ICT was used in the teaching and learning of A-level Physics in schools in Manicaland in Zimbabwe. A holistic perspective used Cole's (1995) garden-as-a-culture metaphor as a framework to give a broad view of the extent of use of ICT in selected schools in Manicaland. The literature was used to document the external environment of ICT mediated teaching and learning activity system. A-Level teachers, students and computer specialists from 10 schools participated in the empirical study and supplied data mainly through self-reporting questionnaires, informal interviews and focus group discussions. The researcher was a non-participant observer.

The aim of this chapter is to synthesise the findings of the study and relate these to the literature review to address the research questions. The research questions are brought forward from Chapter 1 to provide the organisational framework for this chapter:

- Which of the teachers are using ICT in A-Level Physics?
- How do the A-Level Physics teachers view the exclusion of any reference to use of IT in the ZIMSEC syllabus 9188 in comparison to the former UCLES syllabus 9244?
- To what extent are the teachers using ICT in of A-Level Physics?
- To what do teachers ascribe their capacity and interest in using ICT in A-Level Physics?
- How is the teaching and learning environment changing as the result of teachers using ICT in A-Level Physics?

After addressing these research questions, the chapter concludes with recommendations including a proposition for an ideal Computer Specialist envisaged to be key in addressing some of the gaps / “fractures” identified in the ICT mediated teaching and learning of Physics in the schools. Secondly three proposals are made and concern the training of Physics teachers; the Ministry of Education goals for ICT; and Internet connectivity in schools in Zimbabwe. Lastly areas for further research stemming from this study are presented.

5.2 Summary of findings

5.2.1 Teachers use of ICT in A-Level Physics teaching

Although teachers and students have adequate access to computers, it appears that Physics teachers across-the-board were apathetic about the use of ICT. Teachers with more than 5 years of experience using the former Cambridge Syllabus 9244 seemed to be as indifferent as their less experienced colleagues who only taught the localised Zimbabwe Syllabus 9188. Neither the type of school nor the presence of suitable ICT infrastructure seemed to make a difference. However the Physics teachers were all male, leaving open the question of whether gender would have made a difference.

5.2.2 Teachers' views on exclusion of reference to use of ICT in Syllabus 9188

According to the teachers, the exclusion of Aim 5.3 in the ZIMSEC Syllabus 9188, that would have stipulated use of ICT as in the former Cambridge Syllabus 9244, was an ill-timed and erroneous omission, which according to some of the teachers, deprived students of exposure to use of ICT. Thus despite the apathy in the use of ICT, the teachers positively subscribed to the idea that the use of ICT should be integrated in the Physics curriculum.

This exposed the paradox of the Physics teachers having a positive attitude towards use of ICT in their subject, yet the dearth of practice by the same teachers. Reconciling the two positions required a closer look at the data from the community of the school activity system to generate an explanation.

There had to be explanations derived from the activity systems of the school, the Education system and society at large. The education system and the Zimbabwean society were dealt with in Chapter 2, while the school cases were described in Chapter 4. It was established from the literature that the education system in Zimbabwe is a product of two eras: pre- and post-independence. One thing that has dominated both eras is the focus on examinations at the expense of sound pedagogy. Both teachers and students are under pressure from society to achieve good grades on a school certificate. Another factor that would influence teachers' views of ICT is the fact that it is only in this decade that a reasonable number of computers have been procured for schools. However both rationale and policy have lagged with this influx of computers in schools. In like manner while a good range of ICT artefacts are now in the schools, it would seem that skills upgrading for the teachers as well as sound educational theory and philosophy supporting teaching with ICT has not moved at the same pace as the inflow of the technology. Thus in as much as the Physics teachers have a positive attitude appreciating ICT capabilities in teaching, they shy off using the technology.

5.2.3 The extent of teachers' use of ICT in A-Level Physics teaching

Despite the presence of apt ICT infrastructures in the schools, in case after case, it was rare to come across any significant use of ICT in the teacher's instructional practices. Teachers struggled to remember when and how they had used the computer facilities in their respective schools. The few who remembered, mentioned typing notes for students or searching for old examination papers. Really good examples of best practice in the use of ICT were absent. Physics teachers seem bent on traditional instructional methods: mainly the lecture method and note dictation. Some illustrations to this effect include, *heads down for dictated notes in the Physics lab*, photo S6 (appendix 6.1.6), *the chalk and talk* photo S7.2 (appendix 6.1.7). An alternative method was a group discussion with the textbook as a handy resource, photo S3.2 (Appendix 6.1.3). Physics practical work was also done with the traditional tools for data processing which include the hand held calculator, graph paper, ruler, pencil and rubber.(photo S5 Appendix 6.1.5)

As far as use of ICT in teaching is concerned, the Physics teachers appear be onlookers, hesitant and unsure where to start using the technology in their teaching. This lack of use corroborates with what Ottenvenger et al. 2003:10 reported, *"… in Zimbabwe it is observed that computer and ICT, video disks and other electronic media are not yet being used much in schools for concept development. ICT is rarely used as part of teaching and learning material."* As Rodrigo said about Metro Manila, in Zimbabwe "… ICT remains on the periphery of the teaching and learning process" (2003:119).

In the cases in this study ICT remained on the periphery of teaching with uses in administration mainly for typing and in Computer Studies for learning about computers. Traditional forms of teaching were firmly in place - including the use of textbooks and chalkboards to support lecture recitations. This level of use is classified by UNESCO (2002) as the "emerging" phase on a five level scale or in the "entry level" of Dwyers' scale (1990 in Twining, 2003).

From the findings, it is possible to deduce Physics teacher groupings on their stance as regards use of ICT:

Emerging groupings of the 15 teachers	No. of teachers	% of teachers	Teachers' schools
o Those with no motivation /resistant.	1	7 %	S5
o Those who are purely traditional (don't seem to be aware)	3	21 %	S1, S2
o Those who are waiting for the school administration to do something (for computers to be handed to the Physics department)	4	26 %	S7, S10
o Those who know (in theory) the value of ICT in teaching but not applying it	2	13 %	S5, S8
o Those who are keen but seem unsure how to start	4	26 %	S3, S4, S6
o Those strongly feel access is the problem else would use ICT.	1	7 %	S2

5.2.4 To what do teachers ascribe their capacity/lack of capacity and interest/disinterest in using ICT?

There were two major strengths that surfaced in all the cases studied. Firstly all the schools studied each had suitable ICT infrastructure in place. T3 for example said that availability of computers at S3 motivated him to want to use ICT in teaching Physics. Secondly the teachers expressed a positive attitude towards the use of ICT in teaching and learning. To what then did the teachers ascribe their failure to integrate ICT into their instructional practice?

- **Shifted blame to those in authority**

Teachers shifted blame to authorities. To some extent it would seem that some school administrations were too strict on teachers' access to computers, to the extent of locking away computers in storerooms under the guise of security. The result was that many teachers reported that they had no access or limited access to the computers in their school.

- **Lack of an ICT policy at both Ministry and school level**

The lack of an ICT policy at both Ministry and school level contributed to the non-use of ICT. In Zimbabwe there is a top down management structure. The school heads, teachers and students are used to operating on directives. This expected directive in the form of a Ministry ICT policy was absent. In turn, school ICT polices were not in place to direct how ICT infrastructures in schools could be used optimally. Thus while some teachers expected to have their subject timetabled for the laboratory to use computers, this was not the case in the schools.

- **Monopoly by students taking computers as a subject**

"These (computers) are specifically for students studying computers and they should not be removed from the lab" T6.1. This Physics teacher recognised the prerogative given to those who took computers as a subject. This constrained his capacity to use the computers in his teaching. Such a barrier corroborates what Rodrigo (2003:118) reported when she said that if computers were housed in computer rooms or laboratories, non-ICT teachers were less likely to use them for instructional purposes

- **ICT as Object**

Gaining knowledge about computers was taken as an end in itself (Rodrigo 2003: 116). This resulted in the Physics teacher isolating himself from ICT, dismissing it as another subject just like Physics or Mathematics offered to students who had to get a good grade at the end of the course. This resulted in students bringing to A-Level knowledge about computers and a repertoire of skills that were largely never used. In other words, having done a computer literacy course or having passed a course such as Computer Studies or ICDL was deemed enough. This bookish knowledge is common in Zimbabwe and is what Nziramasanga (1998) lamented: "…the secondary school system became obsessed with bookish education leading to 'O' and 'A' Level examinations" (Nziramasanga 1998:300), as discussed in Chapter 2.

Subject to further investigation though, it appears that the students' knowledge and skills about ICT became a threat to some teachers who didn't share these skills. For example only 4 of the 15 teachers indicated that they would request assistance from a student in using a computer. For the rest, it would appear that this might undermine their authority as teachers traditionally being the source of all knowledge.

- **Awareness and staff development**

Some artefacts such as data loggers were unknown to the Physics teachers because of non-availability in the school. Even for some schools that could afford the equipment, these might remain unavailable unless the teacher was aware of the devices and indeed took the initiative to order them. This is similar to a Namibian experience (Ottenvanger, 2003) where the equipment was available, but largely unused. Ottenvanger (2003) explains this in terms of lack of balance between investments into infrastructure, educational software, knowledge and skills of users and educational philosophy. What seemed to exacerbate this situation further was that most donors have found it easier to invest in ICT infrastructure (computers and connectivity), and perhaps to a certain extent educational software by way of some CDs, than in teacher training and professional development. This concern is echoed in the words of Rivero (1999) that opened this chapter: "You may have the best computer, the most sophisticated curriculum software, and the fastest Internet connection … but if the teacher doesn't know how to use any of that, it is not going improve education "(Rivero, 1999:54).

Perhaps communities in Education systems: Directors of Education, Education Officers, School Heads and teachers should be asking; Now that computers have found their way into our schools, where is the training? Ideally School Heads should first be asking what problems ICTs could address and only then accept them from donors or procure them through various means.

Lack of awareness contributed to the deficit of use of ICT. This was linked to training and skills. The teachers had not received sufficient training on the use of ICT. For most of the teachers the last time they had a stint on ICT was as part of their University or College program. This means that with the average 10 years of experience recorded for this group, most of the teachers received training before ICT was common. Given the rapid growth of ICT, the available ICT artefacts would be new to most of them, as would be the new software.

- **Exam Pressure**

The focus on examinations was found to be a strong factor that might derail any effort to plan for use of ICT. A teacher at one school said that his Physics results were good in 2000 but he never used IT. This teacher's focus was on examination results and he did not see how the use of ICT would contribute to this goal. Another Physics teacher also cited sterling A–level Physics results at his school and hailed the brilliance of his students. This 'good-result syndrome' may warrant further research, but in an education system with bottle necks, where gaining a place at university depends on the scores at A-level, any new teaching and learning tool that is not proven to provide support to this goal may not find favour with the teachers or students. Some traces of ICT use were in evidence where the teacher or student searched a CD with examination material or even the Internet for past examination questions. Lim and Hang (2003:61) found the same, that where schools were examination result oriented; this object conflicted with that of using ICT to engage students in higher order thinking.

5.3 How is the environment changing?

Despite the advent of ICT in the schools, Physics instructional tools remained largely traditional in the ten schools surveyed. Teachers planned for chalk-and-talk lectures for the content delivery and only planned for practical work that prepared students for practical examinations. Teachers mainly taught for examinations. All these findings echo those of Nziramasanga (1999) and Ottenvanger (2003). However in spite of the teachers largely ignoring use of ICT in their lessons, a handful of students were making discoveries exploring CDs and the Internet after class. The extra-school use of ICT by students raises some hope for bringing some element of change in the way students are taught and learn Physics. This extra-school use of ICT that Fluck (2003:126) called 'off-site learning' may enable the extension of school resources to after-hours. This is where homes become part of the school thus allowing, for example, students to access and finish off homework and send it to the teacher. The implication is that while Physics teachers may choose to remain traditional, they may find themselves under pressure to change even their roles within the division of labour arm of the ICT mediated class activity system.

5.4 Recommendations

Considering the state of presence of ICT artefacts in the schools and empirical evidence of fractures in the activity system of ICT mediated Physics teaching and learning, this section proposes an Ideal CS and provides three other recommendations in the area of training, Ministry goals and connectivity for schools.

5.4.1 The Ideal Computer Specialist (ICS)

The Physics teachers worked in isolation with limited ICT skills and insufficient awareness of the potential of ICT in their teaching. Few sought help from the CS. In view of the findings in these case studies, both the teacher and the CS should play crucial roles in the division of labour within the community of the Activity system where ICT is used in the teaching and learning of Physics. Drawing on the examples of some aspects of good practice from the computer specialists (CS3 and CS5) at two of the schools and from the literature, an ideal computer specialist (ICS) is proposed for schools that may want to see Physics teachers and other subject teachers begin to use ICT for teaching and learning. The ICS can mediate the transition from the current situation where the computer is taken as an object of study to where it is viewed as a tool for teaching and learning.

Ideally the ICS is relieved of teaching assignments to allow for ample time to "dream" about and research on how ICT could be integrated into the various subject areas within the school curriculum. Like CS5, the incumbent ICS becomes the systems administrator cum network administrator and local computer technician. Like CS3 and CS5, the ICS maintains ICT infrastructure locally and only outsources second level support for major repairs and expertise. Like CS5, the ICS uploads curriculum material CDs on to the LAN file server and monitors access to the material by all users. Like CS3, the ICS becomes the webmaster, building and maintaining the school research intranet, relying on and coordinating the subject specialist on what material to be uploaded onto the intranet. Like CS3, the ICS becomes the Head of Department (HOD) ICT. As HOD, the ICS spearheads formulation of the school ICT policy working with subject HODs in the school and possibly the deputy head. Like CS3, HOD level position in the school is senior enough to empower the ICS to build scaffolds for subject specialists, advising them on innovative ways of using ICT in teaching and learning. In this position the ICS is empowered to support teachers in the use of the ICT infrastructure, building the user teacher's self-efficacy.

5.4.2 Physics Teacher Training

Based on the findings in this study, there is a need for training to raise the Physics teachers' awareness, ICT skills level and the philosophy of teaching with ICT. The ICS should be able to organise such local training initiatives on-site and off-site. Particular attention would need to be given to the integration of ICT within Physics lessons where students are required to use the computer to attain particular learning outcomes. This would enable the teachers to make optimal use of the skills that students already possess or could learn quickly.

5.4.3 Ministry Goals

The Ministry of Education would need to revisit the rationales for ICT in schools (Hawkridge 1990) and demote the goal that promotes computers being studied as an "object" with students gaining knowledge about computers as an end in itself and promote ICT as a cross-curricular tool that can transform classroom practice. This is in line with current trends where "with the increased popularity of computers, today's students are learning with technology as opposed to learning about technology" (Trinidad et al. 2001).

5.4.4 Connectivity for schools

The dial-up system on limited bandwidth used for Internet connection in schools is untenable. The Internet cafes where some students in this study offer broadband and other better options than the dial-up system in the schools. The challenge is for society at large (chapter 2), the business community and relevant government ministries to together work out goals for the provision of better connectivity for schools.

5.5 Further Research Agenda

The study raised many questions and pathways for further research. Firstly there is need for some follow up on the role of the ICS, which seems a likely pathway to address the reality of the apathy among the Physics teachers on the use of ICT. Secondly staff development for Physics teachers at two levels; in-service and pre-service would need to be looked into. Thirdly the study hinted at the underutilisation of ICT infrastructure in the schools; it would be interesting to determine the uptime of computers in the schools together with other indicators of use. The thesis here is that the same infrastructure in each school can be optimally used for teaching and learning if the computer idle time were redeemed.

Fourthly Physics teachers did not use generic software such as MS-Excel. There is opportunity for development of instructional and learning material based on generic software available on the computers. To this Heide and Handerson (1994:28) said on Multimedia “Breaking new ground in the use of Multimedia does not have to be prohibitively expensive … The first place to look for equipment is your school’s existing inventory, the already owned …”

Lastly, but not least, the extra-school use of ICT that surfaced in this study is a resource available to some students but used for miscellaneous purposes. This creates an opportunity for further research into how this resource could be tapped into to enhance learning of Physics.

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6.0 Appendices

6.1 Case Stories (Appendix A)

6.1.1 School S1

Record:

20 computers	28 A-level physics students	950 students	37 teachers	Group A

Photo S1 Form 3 Computer Studies

About the school

This group A boys only boarding school located in the low-density area of the city of Mutare was visited on 24 July 2006. There were two physics teachers taking A-level physics classes of 15, and 13 students in Form 5 and Form 6 respectively.

The computer specialist (CS) with a B.Ed. in Maths and HND in computers looked after the computer lab. His main focus was in teaching computer studies for good exam grades even though he doubted the relevancy of the syllabus.

Infra structure appearance

Of the 20 computers reported to be in the school 12 were in the Computer lab; among them five Pentium 4 (P4) type with 2.4 GHz processor, 40 GB Hard drive, 128MB RAM and *Windows XP* as the operating system (OS). There were also clones with 233 MHz, 10 GB Hard drive (HDD) and 32 MB RAM. Among them was a Macintosh (on the right in photo S1). These personal computers (PCs) were stand-alone with no attempt towards networking. The Schools Development Association (SDA) purchased the computers. On the day of the visit four of the machines were out for repairs having blown power supplies. There were no surge protectors as a precaution. On the second visit for data verification a form 3 Computer Studies class of 25 students, shared 3 working computers (groups in photo S1); Some of the computers especially those running on *Windows XP* had booting problems.

Computer Lab use

There was trivial activity in the computer lab. During the first visit, four Form 4 computer Studies students were in the lab seeking advice on their ZIMSEC exam projects. The lab is solely intended for students doing computer studies. At most 2 periods per day, was the average time allocated to a subject on the school curriculum. The duration of a period was 35 minutes inclusive of 5 minutes change over time (students walk to the lab). Computer Studies had 2 such periods a day. Thus on average the computer lab was used for 2 hours a day (1 hour for the Form 3 class another for the Form 4 class) During the second visit students took turns to play games on the three working computers. An example is the student on the computer to the left playing solitaire (Photo S1).

Computer specialist comments

Efforts to garner support for an ICT policy the CS were fruitless. He also indicated that the Lab computers have not been serviced since 2004. However an external company maintained those in Administrative offices separately. In the absence of power surge protectors four P4 computers had power supplies blown.

Use of ICT in physics

This school took computers as an object of study; Computer Studies only was on offer and counted as one of the practical subjects. Physics is another subject in the school curriculum divorced from ICT. Both teachers at this school report use of e-mail for *personal* business not related to teaching. (T1.2, T1.1). Traditional teaching methods prevailed in the Physics lab.

6.1.2 School S2

Record:

25 computers	33 A-level physics students	1200 students	65 teachers	Group B

Photo S2 Physics Teacher in lab after Practical Test

About the school

This group B day school is in the high-density area of the city of Mutare. There were two physics teachers taking A-level physics classes of 13, and 20 students in Forms 5 and 6 respectively. A young lady in the mid 20s with a B.Sc. Maths + Dip. IT. + Dip.Ed, was the CS in charge of the computer room. She was also teaching A-level statistics in addition to computer studies.

Infra structure appearance

On the day of the initial visit, 25 July 2007, the Computer lab was open but with one stand alone computer on which a student was typing a document belonging to the Deputy Head. The rest of the computers were said to be locked away. When the school was revisited on 1 Nov 2006 for data verification still one computer was in the lab but a different one: a P4 Compaq HP 2.8 GHz processor, 80 GB Hard drive, 256MB RAM with on-board network card and a flat LCD screen. The CS was typing end of year computer studies exams for forms 3 and 5. In the science lab one teacher was busy setting up another Compaq HP, but matched to an IBM monitor. The computer had been borrowed from the storeroom for the purpose of typing her end of year science exam.

> *At the same school where one teacher X says computers are not accessible for teaching physics, another teacher Y gets one to type exams. This is a pointer to a multiplicity of variables underlying use of ICT in teaching*

Computer Lab use

◊ The CS reported that computers were particularly for students doing computer studies and were brought into the lab only when needed for their lessons.

Computer specialist comments

◊ The computers are locked up somewhere.

Use of ICT in physics

◊ The thrust was on computers as object -Computer studies. The form 5 physics teacher less than a year in the service with some ideas and eager to try out ICT in physics but says he had no access to computers. Meanwhile physics practical experiments (practicals) were done in preparation for examination practical, for example simple pendulum (photo S2). These test a given set of skills and usually they are not for concept development.

Head's Comment

We have computers but no space for them. We are planning to use a room that was intended to be a library as our new computer room. Our teachers here do not use computers to teach physics. You won't see this. No; (shaking head). As for internet I would rather have a system where students pay first before they use it, not to pay after that won't work. Anyway our students get a lot from the café's in town.

6.1.3 School S3

Record:

16 computers	26 A-level physics students	450 students	40 teachers	Group C

Photo S3.1 Server in Computer lab with subject portals

About the school

This is a private school located 10 km from the city of Mutare. It is a boarding school but takes day scholars too. At the time of the visit on 1 August 2006, one teacher with close to 20 years experience was in charge of both A-level physics classes of 13 students each.

Photo S3.2 Physics discussion using text book

Infra structure appearance

- ◊ One IT teacher (CS), with the title Head of Department IT, manned the computer lab that had with cooling fans in place. All 10 Computers in the lab were on a local area network.
- ◊ The lab was standardised with Mercer PCs, P4 mother Board 3.0 GHz processor, 80 GB hard drive and 256 MB RAM, Photo S3.1

Computer Lab use

- ◊ The lab timetable had free slots such that a student not having lessons was free to get into the lab. The lab was used for ICDL course for students. Teachers were also free to use the lab when free.

Computer specialist comments

- ◊ The CS was building the school research network, which is a local initiative portal with various subject web pages. These were placed on the local server. On the portals downloads from the internet could be viewed off-line.
  The CS however lamented that subject teachers were not forthcoming to edit and make contributions to the intranet. The CS was taking advantage of a sound background in web design and PC maintenance. He did servicing and general maintenance of the computers.

Use of ICT in physics

On the physics portal http://server/physics/optics.htm, some physics resources were available. However the coverage was well above A-level.
There was a computer in the science preparation room accessible to the physics teacher. This computer was mainly used for Department administration work to include filing of exam papers. The physics teacher's interest was on CDs from Cambridge on exam papers, reports and syllabuses. The school followed the Cambridge syllabus Physics 9702 which replaced 9244.
On the day of the visit students in the physics lab were discussing in groups using a text book, Photo S3.2.

6.1.4 School S4

Record:

30 computers	21 A-level physics students	950 students	65 teachers	Group C

Photo S4.1Physics Practical Test

About the school

This is a Mission boarding school 15 km from Mutare separated from Africa University by the road to Nyanga town. Two A-level Physics classes had 13 and 8 students in Forms 5 and 6.

Photo S4.2 Computer literacy class

Infra structure appearance

The computer lab was manned by a young man of about 30 just a year in the field having obtained a Dip.Ed. (Computer studies). There were 26 computers in the lab; most of them top of the current range of PCs; P4 motherboard, 3.0 GHz processor, 80 GB Hard drive, 256 MB RAM with 17"screens and optical mice (Photo S4.2). Ten of these computers were donated by the resident government minister. A 16-port hub sat at the teacher's desk, with no housing and the cabling was exposed. The networking job was incomplete. The wooden floor had grooves that would accumulate dust.

Computer Lab use

On the date of the initial visit, 28 July 2007, the lab was locked. It was however opened on request for the audit. Computer studies course was discontinued as a subject and plans were under way for computer appreciation course for all students. There was no clear timetable as yet and there was no activity in the lab. During the second visit a form 3 class was doing computer literacy (Photo S4.2).

Use of computers

Computers at this school were likely to be used for computer appreciation and skills courses.

Computer specialist comments

Relations between the computer teacher and the school head were unpleasant. Keys to the computer lab were withdrawn from this teacher who had to ask for them from a senior teacher when use of lab was required

Physics Teacher

The physics teacher was frank and of the mind that integrating ICT in teaching was the right way to go but he himself lacked the skills to do it. He expressed very little knowledge even about generic computer programs. The chalk and talk method prevailed in the physics lab. Practicals were done in preparation for the practical exam (Photo S4.1, a practical test with the common stop watch –simple pendulum oscillation experiment).

Reflections/ Emerging issues

- State-of-the-art computers in a potentially dusty environment
- Big gap between a good /suitable infra structure and utilization especially for teaching and learning
- A case of some physics students who have computer skills well above their teacher *(Both students S4.1 and S4.2 reported use of ICT tools for physics especially at home while their teacher T4 reported lack of knowledge of ICT tools to include a spreadsheet. On Skills where the students expressed confidence their teacher indicated "unknown" to the given tools and overall self- scored as beginner)*
- Case of physics students who get help from mother, father's work place also interesting

The Infra structure is "ripe" but the physics teachers are not ready!

6.1.5 School S5

Record:

40 computers	22 A-level physics students	700 students	36 teachers	Group C

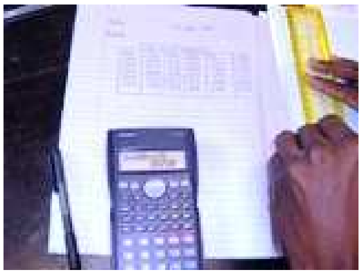


Photo S5 Physics Data Processing

About the school

This mission boarding school about 80 km from Mutare was visited on 31 July 2007. There were two physics teachers taking A-level physics classes of 13, and 9 students in Forms 5 and 6 respectively. The computer specialist (CS) with a B.Sc. Computer Science looks after the computer lab. The second physics teacher also teaches computer appreciation courses to students.

Infra structure appearance

- The computer lab was standard with a server room. There was a mixture of clients, including P4 machines, 2.0 GHz processor, 20 GB Hard drive, 64 MB RAM P2 motherboard 233 MHz processor 10 GB Hard Drive 32 MB RAM under a Linux server. The school also had a laptop computer. This was in administration.

Computer specialist comments

The CS administers the Linux server and carries out basic maintenance.

Computer Lab use

The lab was scheduled for Computer Studies, Computer Literacy, and free will use. This lab was fully in use during the visit.

Use of computers

A trial run to allow students access Internet for a fee was abandoned. Internet was only made available for specific learning assignments. Staff could log in on a department ticket and department budget debited.
On this day a mixture of students of various levels was in the lab, each one doing their own thing. Most in pairs were browsing through a CD, Encarta 2003 on the network. Here they located and discussed information mainly on sciences and geography. The majority were Form 2 and 3 pupils. The CS remained in his glass server room cum office while the students were busy on their own, adequate proof of their CD browsing skills.

Use of ICT in physics

Teaching remained traditional with use of textbooks and the chalkboard. In exam type practical experiments the scientific calculator, pencil, ruler and graph paper were the handy tools (Photo S5).

6.1.6 School S6

Record:

23 computers	39 A-level physics students	730 students	35 teachers	Group C

Photo S6 Heads down for dictated notes in Physics lab

About the school

This is one of the popular mission boarding schools on a hill 24 km from Mutare. On July 27, 2006, there were two A-level physics teachers with 18 and 21 students in Forms 5 and 6 respectively. There were also two computer teachers (CS), the senior; a lady with an ICDL qualification was the respondent. She had been teaching Computer studies, and ICDL to selected classes for 5 years. Her wish was to enroll at a teachers' college to train in the teaching of computer Studies

Infra structure appearance

There was a Computer lab + server room + one room with older type machines no longer in use. The lab had 20 P2 machines, 2.0 GHz processor, 20 GB Hard drive, 64 MB RAM P2 motherboard 233 MHz processor 10 GB Hard Drive 32 MB RAM connected to a *Windows 2000* server in standard design server room. It was reported that the computers have been down for sometime. The school was let down by the company from town that was meant to service the computers. The company had not helped to keep the network up and running including Internet connectivity.

Deputy Head comments

- *The computers have been down for sometime but we have invited a company from town to revive them so that the students may finish up their projects. At the moment we are only allowing those doing their O-level projects to be in the lab.*

Computer Lab use

- The twenty computer studies students were found busy with the project in the lab. The project is an assessment requirement for O-level certification in computer studies as a subject.

Use of ICT in physics

This school took computers as an object of study, Computer studies and ICDL were undertaken to fulfill this objective. Physic was divorced from the ICT infrastructure.
The only ICT related item was the Cambridge A-level physics syllabus available on CD. Meanwhile in the Physics lab it was traditional chalk and talk method that prevailed. Students took down notes dictated by the teacher (Photo S6)

6.1.7 School S7

Record:

80 computers	27 A-level physics students	740 students	37 teachers	Group C

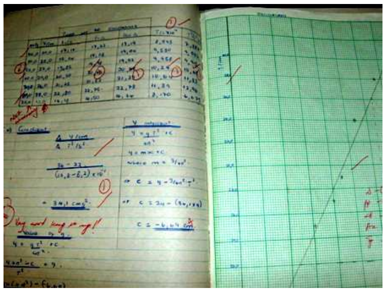


Photo S7.1 Manual Data Processing in Physics

About the school

This Mission boarding school is 17 km outside the small town of Rusape which is 100 km from Mutare. There were 14 and 13 students in Form 5 and Form 6 respectively.

Photo S7.2 Chalk and Talk in the physics lab

Two teachers taught the Physics classes and two computer teachers manned the computer labs. The school was visited on the afternoon of 31 July 2006.

Infra structure appearance

There were two spacious computer rooms, one lab with 20 Asus machines 500 MHz processor 10 GB Hard drive 64 MB RAM and second lab with twenty- 486 machines. Another 20 were said to have arrived and still in boxes. Computers in offices and those locked away added to another 20. Multimedia speakers were also available. The NGO donation pack included subject related CDs including physics ones.

Computer Lab use

The computer lab was scheduled for computer studies, and computer appreciation courses

Use of computers

Computers are mainly used for computer literacy and vocational level courses for students and not for teaching purposes

Students did practical experiments in physics, recorded results, did laborious calculations and drew pencil and paper graphs, Photo S7.1. The teachers use the lecture method, Photo S7.2. Despite the many computers in the school (80), Physics teachers and students had not taken advantage of the available ICT tools. For comparison the Maths department at this school had a share of computers. Time did not permit to delve into how they (Maths teachers) got their allocation.

6.1.8 School S8

Record:

50 computers	28 A-level physics students	530 students	28 teachers	Group C

Photo S8 Twin network switches in Junior lab

About the school

This is a Mission school for boys 38 km from resort town of Nyanga. Nyanga is 110 km from Mutare. A-level physics students were 12 and 16 in Form 5 and 6 respectively. The School has reputation for excellent national exam results. The 2005 Physics Results were 5 A grade and 6 B grade to make the 11 students (on a scale A to F where A is distinctive and F is a fail). Reasons for such sterling performance are beyond the scope of this project.

School has an O-level section (Junior School) and A level section (senior school) physically separated at about 500m

Infra structure appearance

A new computer center was recently completed at the Senior School and 20 computers, P4 2.0 GHz processor, 80 GB Hard drive 128 MB RAM were already in the new computer center and networked. Rooms that can take more computers in future were in place. The junior school had 20 computers 1300 MHz 20 GB Hard drive 128 MB RAM in a standard lab and networked locally (Photo S8). However at the time of the visit this lab was down with power supplies for all 20 having been struck by lightning.

Computer Specialist's list of CDs

There were two computer teachers. A collection of CDs in various subjects including physics was available.(GCSE key stage 4 Physics GCSE Physics: Force, Motion GCSE Physics: waves, optics; GCSE Physics: Matter, Earth, Stars; GCSE Physics: Electricity, Magnetism)

Physics teacher comments

> Physics students that enroll at this school are very capable. As their teacher you really have to know your staff to be able to 'last' at the school. If you survive your first month at the school then you know you are good because they really put you to the test. If you are not prepared for a lesson just send them to the library. These students can actually score at least a C grade in physics without a teacher.
>
> The school is well equipped for Physics teaching. ICT could be useful for experiments not possible in the lab. The biggest barrier in introducing ICT is the cost. I don' t think the school can afford the cost of maintenance. In any case students here will only appreciate it if it will help them pass well.

The teacher did not see any good reason to go for ICT tools when students perform so well without them.

A parent Comments

- "My son says he is dropping computer studies because he doesn't want to spoil his O-level Certificate. He and his classmates are competing to get all As. Computer studies may give him less than an A, and he doesn't want that. He would rather not write the subject."

Computer Lab use

There is a clear time timetable. Guidelines to students on lab use were on the notice board signed by HOD computers.

Use of computers

Computers were used for computers as a subject and for literacy courses. The Physics did not use ICT for teaching.

6.1.9 School S9

Record:

48 computers	26 A-level physics students	680 students	32 teachers	Group A

Photo S 9.1 Reserved for 2 students

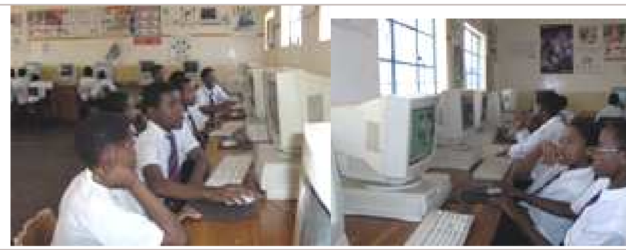


Photo S9.2 Busy Junior Lab

About the school

A 32 km rough road from Nyanga town leads to the Mission school. Nyanga is 110 km from Mutare. The school was visited on 5 Nov 2006.There were 16 students in Form 5 and 10 in Form 6 without a teacher

Infra structure appearance

- There were two computer labs with 24 computers each. The junior lab had two air conditioners, 19 machines (a mixture of 233 MHz processors most running on 32 MB RAM and 5 GB Hard drives} running, a scanner and a printer. Likewise the senior lab had a fan, and was well curtained. However fine dust, red soil type had settled on the larger part of the lab's good furniture where 18 of the computers stood out of use. The 6 working computers 1300 MHz 40 GB, Hard drive128 MB RAM in the senior lab were smoothly running on *Windows 2000 professional.*

Computer specialist comments

The computer specialist was not sure about where the physics CDs were kept.

Computer Lab use

- The junior lab was in full use at the time of the visit. Form one classes were taking turns on one-hour sessions. Three classes had a chance during my visit from 10am to 1.00pm (Photo S9.2) Two A-level computer science students working on their projects occupied the 24-computer senior lab (Photo S9.1)
- Once in a while junior students in pairs or threes sneaked into this lab to visit the remaining 4 out of the six working machines either to play a musical CD or try and find their way round a password-protected screen.
- Students who sneaked into the senior lab were intimidated by the teacher who once in a while popped in. "These things will make you fail. Leave these two (A-Level Computer Science students) alone . They are busy working on their projects, which will make them pass while you are playing. You better leave this room and go and study", he would say.

Use of computers

- The Junior lab was timetabled for literacy courses. On this day the teacher said he had nothing specific planned but allowed the pupils to play games.
- The second lab is used for computer science lessons currently with 2 students**.**

Deputy Head's Comments

On reading my letter of introduction the deputy Head had this to say:

> *I think you will have a slight problem. Except for a few CDs, our teachers have not gone as far as using computers in their lessons. We however have students, a few though, who are taking the combination Mathematics, Physics and Computer Science. Again that combination is not popular, I think only two students in the current intake are doing that. The A-level physics teacher at this school left the school for greener pastures last month.*

6.1.10 School S10

Record:

30 computers	15 A-level physics students	900 students	45 teachers	Group C

Photo S10.1 Literacy Class

About the school

This Mission school for girls 73 km from Mutare is one of the popular schools also renowned for good exam results. As a result its student catchment area is nationwide. At the time of the visit, landscaping of the entrance to the administration block was in progress, an innovation that would change the frontage of the school. There were two physics teachers taking A-level physics classes of 9 and 6 students in Forms 5 and 6 respectively

Photo S10.2 Physics Apparatus in typical storeroom

At this School I was privileged to be in the physics lab where I taught A-level physics for 5 years before moving to my current position. (Researcher)

Infra structure appearance

The computer lab houses 24 computers, which are networked with a Linux server. Six were P4 motherboards with 2.0 GHz processors 40 GB Hard drives 128 RAM. The rest were 500 and 700 MHz 32 and 64 MB of RAM (Photo S10.1) Two teachers were in charge of this lab, one with Dip.Ed., Dip. IT and National certificate in computers and the other with Dip. Ed. (computer studies)

The school head's office is well set up with has top of the range computer and LaserJet 1020 printer

Computer specialist comments

- The school once offered computer studies and ICDL, which were abandoned; now replaced by computer appreciation courses. One of the computer teachers was looking for the programs C+ and visual basic, with the mind of reintroducing computer studies. Internet is available for teachers but not for students. A handful of teachers frequently visit the computer room notably the biology teacher. The rest of the teachers don't.

I stayed in the lab over lunch hour during which the biology teacher had asked for keys to the room. A second teacher (maths) also came in and typed a document in *Ms-word.*

Computer Lab use

A timetable for a Forms 1 – 4 Literacy program was on display on the notice board. A-level classes are not on the timetable

Use of computers

At this school Computers were mainly used for computer literacy.
(Photo S10.1)

Physics student comment

"We went through the syllabus without seeing the actual things in most cases for example in electronics, logic gates and amplifiers; we just talked about them. But I enjoyed most the theory of fluid mechanics."

6.2 Detailed Results Analysis sheets

6.2.1 A-Level Physics Teacher (Appendix B1)

A-Level Physics Teacher -Results

1.O **Demographic data**

	BH	Sak	Hil	Htzl	Nyz	SAg	Sfa	Mar	Mag	Bon		
Type of School (p=private, m=mission)	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
School	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Total
1.1 Your e-mail address												
With e-mail address	2	2			1	1	2			2		10
None			1	1	1	1		1				5
Total No. of Teachers	2	2	1	1	2	2	2	1	0	2		15
1.2 Type of school:												
government group A (low density)	1											1
government group B (high density)		1										1
government rural												0
mission school				1	1	1	1	1		1		6
private school			1									1
1.3 Number of A-Level Physics students in a school												
Form 5	15	13	27	13	13	18	14	12		9		
Form 6	13	20	16	8	9	21	13	16		6		
Total												
1.4 Gender of teacher: male	2	2	1	1	2	2	2	1		2		15
female												0
1.5 Age goup: 20-29	1	1					1			1		4
30-39	1	1	1	1	2	1	1	1		1		10
40-49						1						1
50-59												
1.6 Teaching experience: < 1 year		1										1
1-5 years	1			1	1	1	2			2		8
6-10 years	1	1			1	1		1				5
11-15 years												0
16-20 years			1									1
> 21 years												15

2.O **The A-level Physics syllabus**

2.1 A-level physics syllabus currently Followed.

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
School	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Total
A-level Physics Cambridge 9244			1									1
A-level Physics ZIMSEC 9188	1	1		1	1	1	1	1	1	1		9

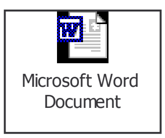
2.2 Did you teach syllabus 9244 before the switch over to 9188?

yes	1	1	1		1			1				5
No	1	1		1	1	2	2			2		10

2.3 Aim 5.3 of the Cambridge syllabus 9244 of 2000 stipulates use of Information Technology (IT) but the ZIMSEC syllabus dropped this aim. Do you think this omission was a good idea?

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
School	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Total
yes					1			1				2
no	2	2	1	1	1	2	2			2		13

2.4 Explain your choice.



2.4 Omission of aim 5.3 in the ZIMSEC physics syllabus: Explain your choice:

T1.1 No, Some concepts such as waves, alternating current, Rectification, Digital and Analogue electronics just to mention a few can make use of computer software as teaching aid.

T1.2 No, Many A-level topics need use of Information Technology eg simulation of waves. Most teachers who are training nowadays they able to use this IT. Therefore what is learnt at colleges is not being applied at school. Some information is found online.

T2.1 This is the Information Technology age and it is the right of every student to be exposed to computers, especially the internet. Also the use of overhead projectors together with Microsoft PowerPoint makes presentation easier and more clear as compared to chalk and magic markers

T2.2 Its good to use IT. As students and teachers will be up to date with technological development.

T3.1 Most schools in Zimbabwe have a shortage of equipment. There is a lot of simulations that can be done on the computer and one computer per school may be enough.

	T4.1 Students need the use of IT as Physicists in their future studies. They will lag behind those who will have studied Cambridge syllabus when they go to university resulting in their studies being affected. Every Scientist need to be well versed with IT as use of it is inevitable in the modern world. T4.2
	T5.1 Dropping this aim does not mean that we will not use IT. IT is an aid, it does not affect results if not used. Generally we do not depend on IT (information Technology) for good results rather IT is an aid which we were able to do without. My physics results were good in 2000 but we never used I.T. T5.2 IT is important for research work
	T6.1 Physics and I. Technology (I.T.) are greatly linked hence the students we produce are not literate technologically. T6.2 There is need for use of 9IT) in the learning of physics. While the inclusion of aim 5 in the ZIMSEC syllabus would be good in pursuance of the above, due to lack of computers in most schools, it would be difficult to implement.
	T7.1 The world is now computer driven. So many areas of physics need IT applications. T7.2 It was not a good idea. It deprives students of modern way of Science Learning and it also complicates the work for the teacher. With a computer it is possible to provide individual tutorials to students easily.
	T8.1 Lack of resources. Many schools are struggling to get basic materials for practicals what more sourcing computers. Computers available in my school are not enough for those doing computers as a subject. Information Technology must be introduced after equipping the schools.
	T9 Teacher left for greener pastures
	T10.1 The use of IT is vital in physics teaching since most of the concepts learnt in physics can be easily demonstrated using computer software. T10.2 IT use in teaching is the future and it makes storage of information and its processing easy. Physics in this age keeps improving and the internet can be a source of current invention and changes in the world of Physics. It is faster and easier for students and teachers to use IT and the internet to research and answer/solve problems.

3.O **Teacher Computer Competencies**

Computer skills that people have vary depending on what they use the computer for.
In this section you are given a list of some of these skills .

Skills rating key

0=nil. You do not have this skill.
1=beginner, you can manage but with some help. =begn
2= confident, you are able =conf
3=expert. You are proficient, very capable=expt

a. Teachers' self assessmement of computer skills.
b. Skills used in A-Level Physics teaching.

			a. rating nil 0	begn 1	conf 2	expt 3	b. skills
3.1	**Word Processing**	Av	1	2	9	5	I use
3.1.1	Inserting pictures, images ,diagrams into a document		1	2	8	4	2
3.1.2	Saving a word document in other file formats eg html			1	9	5	1
3.2	**Core skills**		2	3	4	6	I use
3.2.1	Creating and renaming folders		1	3	4	6	
3.2.2	Saving and finding saved files		1	1	5	7	1
3.2.3	Connecting monitor,keyboard and mouse to computer		3	3	4	5	2
3.2.4	Connecting peripherals such as a data projector, camera, speakers to computers		3	3	4	5	
3.2.5	Scan for viruses		2	6	2	5	
3.3	**Graphics skills**		3	5	4	3	I use
3.3.1	Scanning an image or diagram from hardy copy		4	5	2	4	
3.3.2	Modifying images, diagrams to suit own need		4	6	3	2	
3.3.3	Creating diagrams using tools in a drawing program		3	3	7	2	
3.4	**Internet and e-mail skills**		2	3	5	7	**I use**
3.4.1	Accessing e-mail, making attachments		1	3	6	5	**2**
3.4.2	Searching for information on the www		1	1	3	11	3
3.4.3	Downloading webpages, saving webpages for offline use		1	3	2	9	2
3.5	**Presentation skills**		5	2	4	5	**I use**
3.5.1	Creating a slide show eg in *MSPowerPoint*		5	1	4	5	1
3.5.2	Inserting audio and video clips into a presentation		4	3	4	4	1

3.6 Overall assessment

	For yourself				For your teaching		
How would you assess your ability to use ICTs for yourself in general and in your teaching of A-level physics?	B	C	E		B	C	E
	3	8	4		5	6	3

B=beginner C= confident E=expert

4.O	**Training /past experience**		
	Which of the following describe how you acquired the skills you already have?		
		yes	no
4.1	Formal college/university as part of main course	12	
4.2	ICT literacy course at college/ university	2	
4.3	Self initiative at private college (part-time)	1	
4.4	ICDL course	1	
4.5	Teaching self on the job	7	
4.6	Workshops	3	
4.7	Other *(specify)* Sharing with others	1	

5.O	In using ICT more often than not one needs assistance. Who do you get help from?			
		stimes	often	Never
5.1	Computer teacher	9	3	
5.2	Another physics teacher	1	3	4
5.3	Student in the physics class	4		6
5.4	Other *(specify)*		1	

6.O	**Access to ICT devices**		
6.1	Do you have a computer at home?	yes	1
		no	9

6.2 If yes, what do you use it for? T8 Animation so that students can visualise some of the concepts eg current flowing in a circuit/ storing information/ programming using visual basic

6.3 At your school would you say you have access to computers for teaching A-level physics?

Always	T3	T5.2					2
Sometimes	T1.1	T1.2	T7.1	T7.2	T8		4
Never	T2.1	T2.2	T4	T5.1	T6.1	T6.2	9
	T10.1		T10.2				

6.4 If never, why not? Document

6.4 If never, why not?

T2.1 The authorities are reluctant to release their computers to be used in classes. They seem to consider the expenses that would be incurred (eg internet) more than the importance.

T2.2 Not accessible because there is no mechanism in place for their usage. No computers for maths and science departments except for commercials/ computer department.

T4.1 There are no special periods allocated for the A-level physics teacher and his students to get access to computers and no assistance (meaningful) is likely to be given to the physics teacher and his students.

T5.1 Students have access at their own time and not during lessons. It is not possible to use the computers for teaching physics because we have only one lab for the 700 students we have. The lab is always occupied with computer students. Physics students access the lab at other time not during physics lessons

T6.1 These are specifically for students studying computers and they should not be removed from the lab.

T6.2 The computer lab is only available for computer lessons maybe due to the limited number of computers in comparison to student population at the school.

T8

T9

T10.1 The knowledge and importance of the use of IT in teaching is far from recognition by the administrators and computer department. I strongly feel that they have to visit other schools and institutions for induction.

T10.2 The Administration and Computer Department need to associate with other high schools to see how far the school is in terms of IT development.

6.5 If you have access, what is the student computer ratio fo students per computer

School	1	2	3	4	5	6	7	8	9	10		
Student to computer ratio	n/a	n/a	1	1	1	n/a	1	2		n/a		

6.6 What % of the computers are working all the time when you are using them?

School	1	2	3	4	5	6	7	8	9	10		
% computers working	20'	n/a	100	100	100	n/a	100	75		n/a		

6.7 Is there a computer in the physics lab preparation room?

yes	1
no	8

7.O **Teacher use of ICTs**

Will you please highlight some ways in which you have used computers and related ICT devices in the teaching and learning of A-level physics this year. It will be helpful if you can cite specific lesson topics or tasks your students performed and the computer resources used.

Microsoft Word Document

7.0 Teacher's Use of ICT this year (2006)

T1.1 none this year
T1.2
T2.1 n/a
T2.2 Could not be used since we have no access to ICT.
T3 Typing notes for pupils. Accessing questions papers and examiner's reports from Cambridge exams. Teaching of some topics using physics CDs. Demonstration of experiment work on topics that have experiments work especially on topics that have experiments that cannot be performed in a school lab like Milkan's experiment.
T4 Have not used a computer in any of my lessons
T5.1 I have never really used computers for lessons but for other personal goals I have. I find textbooks sufficient especially when the computer resources are limited. If there were enough resources I would use computers to teach physics.
T5.2 Use of Encarta reference: –students obtained physics notes from Encarta reference dictionary.
T6.1 Never used at all.
T6.2 Only used to prepare notes for the students and also tests preparation
T7.1 blank
T7.2 Using computer simulations to demonstrate a phenomenon e.g. · wave motion
· interference of waves · diffraction ·electromagnetic induction

T8 This year no lessons of this nature were conducted but in the past year
Topics –Radioactivity, Electricity, modern physics (photo electric effect)
T9 n/a tr left
T10.1 Personal research on several topics on the internet. Files downloaded and printed for student use
T10.2 The computer has not been used in class because computers have not yet been bought for the Physics Department. However the teacher used the computer for saving documents, typing, printing as well as exam typing, diagrams and notes preparation
A program for illustrating random nature of radioactivity was used for O-level physics on

8.O **The presence and use of ICT artifacts**

Here is a list of ICT tools. Can you briefly describe in column (*a)* how you have used the technology in A-level physics teaching and learning? In column (b) indicate how often you have used the tool. Use the following key and tick the appropriate box.

0 =na (not available at the school)
?=ukn (unkown to you)
1=never
2=stime (sometimes, once or twice in the term)
3=often (more or less weekly in the term

b.How often have you used the tool?

			na	ukn	never	stime	often	How
8.1	**Basic ICTartifacts**		**0**	**?**	**1**	**2**	**3**	
8.1.1	Laptop		10		3	1		
8.1.2	Printer				3	6	6	
8.2	**Data Capturing devices**							
8.2.1	Data loggers		7	3	2	2		
8.2.2	Scanner		7	2	1	3	1	
8.3	**Drives and storage**							
8.3.1	CD-ROM		4	1		3	4	
8.3.2	CD-ROM writer		4	1	4	5	1	
8.3.3	DVD		9		2	3	1	
8.3.4	Flash memory (stick)		8	2		2		
8.4	**Multimedia**							
8.4.1	Beamer /data projector		9	3	3			
8.4.2	Digital camera		7		5	2		
8.4.3	Large computer screen		6		4	2	1	
8.5	**Internet**							
8.5.1	Crocodile clips program		6	3	4	1		
8.5.2	Physics java scripts		8	2	5			
8.5.3	e-mail		5		4	4	1	
			na	ukn	never	stime	often	How
8.6	**Software**		**0**	**?**	**1**	**2**	**3**	
8.6.1	MSWord				2	6	7	
8.6.2	MSPowerpoint		4	1	4	5	1	
8.6.3	Paint		7	4	1	2	1	
8.6.4	Web authoring tools such							
	as HTML, *Dreamweaver,* etc.		7	4	1	2		
8.6.5	Other *(specify)*							
	visual basic						1	Object oriented programming

9.O **Use of Spreadsheet**

In teaching /learning physics one may use data analysis software such spreadsheet programs. *MSExcel i*s one example.

Which spreadsheet functions do you currently use in A-level physics?

Tick in the box.

?=ukn (unknown to you) 1=never

2=stime (sometimes, once or twice in the term)

3=often (more or less weekly in the term)

		ukn	never	stime	often
		?	**1**	**2**	**3**
9.1.1	Spreadsheet formulas for calculations	1	6	7	
9.2.2	Spreadsheet function for sorting data	1	5	7	
9.1.2	Spreadsheet function for drawing graphs	1	5	6	
9.2.3	"What if function" for relationships between variables	1	7	6	
9.1.3	Spreadsheet formulas for modelling physics concepts		4	8	1

		nill	begn	conf	expt
9.2	How would you rate your spreadsheet skills?	0	1	2	3
		2	4	4	3

9.3 Which of the following spreadsheet functions do your A-level physics students use in completing physics assignments?

Tick in the box. 1=never

2=sometimes, once or twice in the term

?= I do not know if they use this 3=often (more or less weekly in the term)

		?	1	2	3
9.3.1	Sum,divide,multiply,average formulas in physics calculations	3	13		
9.3.2	Rounding function	3	12		
9.3.3	Chart function for graphing data in physics practicals	3	11	1	

10.1 How would you rate the computer skills of your A-level physics students?

?	7
Poor	2
Good	4
very good	

10.2 What computer related courses do your A-level students attend?

T1.1 *don't* know

T2.1 None

T3.1 Information Technology

T4.1 Nil

T6.1 CDL

T7.1 Packaging

T10.1 ICDL

T10.2 ICDL

11.O **Use of the Internet**

11.1 How often do you make use of the internet in the teaching and learning of A-level physics?

Never	T1.1 T1.2 T2.2 T2.4 T5.1 T5.2 T6.1 T7.2 T8	9
sometimes	T2.1 T3 T6.2 T7.1 T10.1 T10.2	6
often		

11.2 What do you normally use the internet for?

T1.1 Never

T1.2 E-mail, downloading and searching my personal information.

T2.1 Searching information for some topics and also to send news happening around the world eg on goggle and BBC web sites.

T3 To search for information that cannot be found in text books eg cell phone technology that is in the new Cambridge syllabus

T4.1 n/a

T5.1 blank

T5.2 Internet not accessible to everyone

T6.1 No access

T6.2 Downloading relevant documents which are physics/science related

T7.1 Search for Cambridge Exams

T8 The modem in the school is not functioning. The facility is in the head's office only.

T10.1 Research

T10.2 Internet access is scarse -Resources are few.

11.3 If you ticked *"never"* in 11.1, briefly say why not?

T1.1 The computers in the school are not connected to the internet.

T1.2 Computers at school are not linked to the internet

T4.1 Not available to physics teacher and students.

T5.2 Internet not accessible to everyone

T6.1 No access

T7.1 Not available

T10.2 No allocation of computersto physics department

12.O **Use of Computer simulations**

12.1 Have you used any simulations in A-level physics?

yes	3
no	11

12.2 If you have, may you give some examples by name or title.

T1.1 superposition of waves, Rectification

T3 GCSE physics CD- ROM, A-level CD -ROM

T7.1 A-level physics

13.O **Use of Physics CDs**

13.1 Have you used any A-level physics CDs?

yes	T3 T7.1 T7.2	T8	4
no			11

13.2 If you have, may you give examples by name or title.

T3 GCE physics A-level CD –ROM for Macintosh 7

T7.1 A -Level Physics

T7.2 For exam questions

T8 Electronic library (many subjects)

14.O **Motivation**

14.1 What can you say is your strongest motivation in using ICTs in the teaching of A-level physics?

T3.1 Availability of computers at Hilcrest and lack of equipment some of the experiments

T4.1 Have not used them at all

T5.1 I have no motivation for teaching physics using IT, my motivation for personal use in other fields not for teaching physics because of limited resources.

T6.2 It saves time and brings about variations in teaching methods

T7.1 Searching for questions

T7.2 For exam questions

T8 Lack of resources and not included in the syllabus so students cannot see the importance

T10 Blank

14.2 What are the challenges in using the ICT tools in the teaching of physics ?

T1.1 Non-availability of software and lack of internet

T1.2 · No internet linkage · no appropriate software · physics/science department does not have computers

T2.1 You have to be updated on what is happening in the IT World every time which means that you never stop learning.

T3.1 It is difficult to keep track of the changes in technology, hence it is difficult to use some of the ICT tools.

T4.1 Teachers are not versed in the tools, maintenance of the tools very expens*ive.*

T5.1 Limited resources and software as our leaders have no money to buy software and other resources especially for sciences.

T6.1 Most students are not computer literate as they may come from rural schools for A-level. Teaching them some of the ICT tool would need an extra lesson

T6.2 · Shortage of computers · Limited skills in use of computers in the teaching /learning process

T7.1 No enough time

T7.2 Using ICT is time wasting especially because of lack of in depth knowledge on ICT

T8 Practical /visual, userfriendly

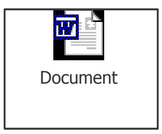
T10.1 Blank

15.O Give your honest opinion about use of ICT in physics teaching
as expressed in the following statements

SD=strongly disagree D= N=not sure
SA=strongly agree A=agree

		SD	D	N	A	SA
15.1	ICT is the "in thing" for teaching A-level physics	1	1	5	7	1
15.2	One can afford to teach A-level physics without use of ICT.	4	1	3	7	
15.3	Bringing ICTs to the physics lab is a hassle	2	5		5	3
15.4	ICT is a must for A level physics teaching and learning.	1	3	1	7	3
15.5	The current A level syllabus is fine without mention of ICT.	7	8	1	1	
15.6	Use of ICT for physics teaching /learning should be made compulsory.		3	2	7	3
15.7	If ICT is used in teaching A-level physics, it will be impossible to finish the syllabus.	3	4	6	1	1
15.8	Use of ICT for teaching /learning is for developed countries.	7	4	1	2	1

16.O **Your final word**
What is your word of encouragement or warning to those
who woud like to use ICT in A Level physics teaching.



16.0 Teacher's Final Word
T1.1 The teachers should be proficient with ICT and the software and hardware be exposed to the teacher. Aspiring schools should computerize physics laboratories. **T1.2** The instructors should be fully exposed to ICT, so that they can implement it well. ICT, makes physics lessons enjoyable and the teacher only edit the notes and the information and well secured for future use..
T2.1 Implement ICT since you have to uplift and enlighten the deprived young generation from the high-density suburbs. The use of ICT may be the beginning of their bright future. Most of these students only hear about computers, they have never used them before.
T3.1 ICT should be used in the teaching of physics but we should not do away with the actual practical component. ICT should not be a substitute of practical work.
T4.1 They should definitely use it as this would produce a complete physics student. This will also make physics teachers complete and worth calling physics teachers.
T5.1 What people think about ICT and what is actually happening may be different. ICT will help me in other areas and not teaching physics entirely. However there are some benefits I derive from ICT in teaching physics like using the Encarta Microsoft dictionary. **T5.2** Adjust school timetable to cater for ICT.
T6.1 I think it is a welcome development introducing ICT at A-level as this equips students in research when studying at University where personal research is important. **T6.2** ICT motivates the students but should be used only when necessary lest physics is turned into computing
T7.1 Keep on doing it
T8 With resources available you can make it.
T10.1 Keep on using ICT if you are already using it or keep trying hard to get access to teach physics using IT **T10.2** IT is the future and our school and all schools should endeavor to and introduce ICTs

The End

6.2.2 Computer Specialist (Appendix B2)

Computer Specialist- Results

	BH	Sak	Hil	Htzl	Nyz	SAg	Sfa	Mar	Mag	Bon		
Type of school [A,B=government]	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
[Cp=private, Cm= mission]	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Total
1.1 Your e-mail address	0	1	1	1	1	1	1	1	1	1		9
1.2 Type government group A (low density)	1											1
government group B (high density)		1										1
government rural												0
mission school				1	1	1	1	1	1	1		7
private school			1									1
1.3 Total enrolment	950	1200	450	950	700	730	740	530	680	900		
Total Number of teachers	37	65	40	65	35	35	36	28	32	45		
Total Number of Admin staff												
1.4 Gender: male	1		1	1	1			1	1			6
female		1				1	1			1		4
1.5 Age goup 20-29		1										1
30-39	1			1	1	1	1	1	1	1		8
40-49			1									1
50-59												
2.O What is your job title in the school?	T	T	IT	T	T/SA	T	T	T	T	T		
2.1 For how long have you held the post? years	12	7	4	1	5	5	5	6	3	10		

2.O What is your job title in the school?

1.Teacher T
3.Head of Departmenr IT.
9. HOD Computers

2.2 What are your post school qualifications?

1 B.Ed Maths + HND Computers
2. BSc Maths+Dip. IT+Dip Ed.
3. ICDL Adv.
4. Dip Ed (Computer Studies)
5 Training
6 ICDL
7. NFC, NC Computer studies,ND E
8. HND computers
9 A level, ND Education.
Micro-computer Technology
10 Dip Education, NC computers
Diploma in Aplied IT

2.3 How did you become a computer specialist?

1.Study of ND,HND, PC maintenance
2. Interest
4. I studied Computer Science as m for my Dip Ed.
5
6. Computer trained
7. Through my training
8. Training
10 By studying

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm
3.O **Infrastructure**										
3.1 Computers :	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
3.1.1 Number of computers at your school in total?	20	25	16	30	40	23	80	50	48	30
3.2.2 Number of working computers in the school?	12	16	16	28	31	15	60	35	32	30
3.3.3 Number of laptops?	0	0	0	0	1	0	0	1	0	0
3.2 Location of computers:										
3.2.1 Is there a computer in the school head's office?										
yes	1	1	1	1	1	1		1	1	1
no							1			
3.2.2 Number of computer labs in the school:	1	1	1	1	1	1	2	2	2	1
3.2.3 Number of computers in computer lab:	12	16	10	26	26	20	40	40	40	24
3.2.4 Number of computers in the physics lab:	0	0		0	1	0	0	1	0	1
3.2.5 Other computer locations in the school.										
1 SDA office, admin office	2									
2 Reception 3. Hostel, buying /stores										
4 Bursar's office, Deputy head's office	2									
5 Library / Admin					2..5					
6 Deputy head's office										
7 Accountant, typist,clerk, Maths Dep							4			
8 Secretary's office, Bursar's office								4		2
9 Maths Dept(2) Admin Offices (4)									6	
3.3 Devices										
3.3.1 How many computers have the following devices?										
1 CD-ROM drive	4	16	16	30	13	2	40	20	12	24
2 CD writer	0	0	1	0	2	1	2	2	1	2
3 DVD drive	0	10	0	0	1	0	2	1	0	2
4 USB port	4	16	10	20	39	20	40	50	24	5
3.3.2 Number of peripheral devices are available:										
1 Printers	2	11	5	4	6	3	14	8	3	7
2 Scanners	0	1	0	0	1	0	0	2	1	0
3 Digital cameras	0	1	0	0	0	0	1	1	0	0
4 Beamers (data projector)	0	0	0	0	0	0	0	0	0	0
5 MODEMs	4	1	3	1	2	1	1	4	2	2
6 Flash memory sticks	0	0	0	0	2	1	0	10	0	0

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Total
4.O Network												
4.1 How many computers are connected on a Local Area Network (LAN)?	0	12	10	0	31	21	18	30	10	10		
4.2 What is the size of the switch /hub *(if any)* in use on the LAN? Number of ports.	0	8x2	8x2	n/a	8x4	16x2	8x4	16x2	16x4	16		
4.3 Which servers, if any, run on the LAN ? 2.LAN suite 2000; 5 Linux; 6. Proxy; 7.Main; 8. File and print servers (win 2000); 9. Win 2000; 10. Linux	n/a	1	n/a	n/a	1	1	1	1	1	1		
4.4 Are there any of the following physics teaching /learning resources shared on the local area network? ?=I don't know.												
1 CDs on physics ?												0
yes					1		1	1	1	1		5
no	1	1				1						3
2 Physics java applets ?												0
yes												0
no	1	1				1						3
3 Physics assignments or homework ?												0
yes								1				1
no	1	1			1	1						4
4 Display of results of experiments, graphs by physics students ?												0
yes												0
no	1	1				1		1				4
5 Powerpoint presentations by the physics teacher ?					1							1
yes												0
no	1					1						2
6 Physics downloads from the internet ?												0
yes			1		1			1				3
no	1					1						2
7 Other *(specify) Biology,Chemistry,*						1						1
Lititerature in English												0
5.O Internet												
5.1 Do you have internet connection at the school?												
yes		1	1		1	1	1		1	1		7
no	1			1				1				3
5.2 what type of connection is it?												
dial up		1	1		1	1	1	1	1	1		8
leased line												
Other (specify)												

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
5.3 How do you rate the connectivity in terms of: 1 getting a connection to the ISP?	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		
very poor						1				1		2
poor			1				1					2
good		1			1				1			3
very good												0
2 average speed downloading files?												
very poor												0
poor			1		1	1	1			1		5
good		1							1			2
very good												0
												Total
5.4 How many computers are linked to the internet?	0	12	2	0	20	20	1	0	2	10		
5.5 Do physics teachers have access to the internet? yes			1		1				1	1		4
no		1				1	1					3
5.6 Do A-level physics pupils have access to the internet yes					1				1	1		3
no		1	1			1	1					4
5.7 Are you responsible for connecting users to the internet yes		1	1		1	1			1	1		6
no							1					1

5.8 If yes, have you had requests from physics teachers for connection? for what purpose?

2. Research
3. Syllabus topics
5. Research, mailing
6.Learning & research
9. Research

6.O **Software**	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
6.1 How many of the computers run on:	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		
MSWindows 95 /98 /ME	8	3	16	14	1	21	10	13		28		
MSWindows 2000 pro/2003	2	3		16					24	1		
MSWindows XP	2	10			39		21	35	6	1		
MSWindows 2000 server					1			2				
Other (specify) win 2003												
win 3.1							20					
MAC OS					1				18			
6.2 What application programs run on the computers? *MSOffice 97/2000*												
yes	1	1	1	1	1	1	1	1	1	1		10
no												0
Open Ofifice												
yes					1							
no												
Other (specify)					1							

6.3 Does the school have any CDs with physics related learning material?

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		
Yes					1	1	1	1	1	1		6
no	1	1		1								3

6.4 If yes, what are some of the CD titles availlable?

5.Encarta encyclopaedia (Ref Library)
Particle mechanics
Letts revision series
6. A-level physics syllabus
7. Physics
8. GCSE key stage 4 Physics
GCSE Physics: Force,Motion
GCSE Physics:waves, optics
GCSE Physics: Matter, Earth,Stars…
GCSE Physics: Electricity, Magnetism
10 Revise GCSE Maths, World book

6.5 How often are the CDs used by:

1 The physics teachers?
5. Often
6 They are rarely used
7. Rarely
8. In most lessons
10. Not at all !!

2 A-level physics students?
5. Irregularly
8. In all researches
10. Not at all !!

7.O Computers in your school may or may not be used for the tasks that follow. For each stated tick *yes* or *no* as applicable to your school.

7.1	**Curriculum: Computers in this school are used for;**	yes	Total
7.1.1	Teaching school level Computer Studies (ZIMSEC A-level syllabus)	///	3
7.1.2	Teaching school level Computer Studies (ZIMSEC O-level syllabus)	///////	7
7.1.3	Teaching school level computer Science (Cambridge syllabus)		
7.1.4	Teaching Vocational level computers for HEXCO examination	//	2
7.1.5	Teaching ICDL	////	4
7.1.6	Teaching computer literacy for all students	////////	8
7.1.7	Teaching computer literacy for A-level physics pupils	///	3
7.1.8	Teaching computer literacy for teachers	////	4

7.2	**Pedagogy: Computers in this school are;**			
7.2.1	Used by physics teachers as a tool for teaching physics	/		1
7.2.2	Used by teachers as a tool for teaching Science subjects	/		1
7.2.3	Used by teachers as a tool for teaching other subjects	///		3
7.2.4	Used by physics teachers for internet searches for physics teaching resources	/		1
7.2.5	Used by physics teachers for e-mail	/		1
7.3	**Administration: Computers in this school are used for;**			
7.3.1	Typing exams	/////////		10
7.3.2	Keeping records of students mark profiles	//////		6
7.3.3	E-mailing official documents	/////		5
7.3.4	Processing fees accounts	///////		7

8.O

8.1 Have you ever given help to the A-level physics teacher concerning ICT equipment used in teaching of physics?

yes			/		/	/	/		/			5
no	*1*			/				/		/		5

8.2 If yes, state the nature of help given.

CS3. Advice on capabilities & poten using computers as a teaching aid
CS5. End user assistance
CS6. Using the CDs
CS7. Using CDS on physics to teach the subject
CS8 Information browsing on the net

8.3 How often have you done this?

3.Not more than 3 incidents
5. Rarely/ irregularly
6. Rarely - once
7. Rarely
8 Not often

9.O How many of the computers in your school were:

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		
1 Purchased by the school?	all	8	all	20	10							
2 Donated by the President?		10		10	10							
3 Donated by an NGO?		7			21	20	*	50	all	10		
4 Other *(specfy)*												

*Majority donated by NGO

10.O **Maintenance**

10.1 Who services the school computers?

CS1. Lab computers serviced by the
While admin computers are service
at Digital computers
CS2. Time Tec
CS3. Self
CS4. Time Tech Technicians
CS5. Local specialist
CS6. Time Tech Engineers
CS8. IDATA
CS9. Contracted computer companies
CS10. Departmental teachers

10.2 What do you do with those that break down?

1.Send them for repairs
2.Send them for repairs
3. Repair if possibble - depends on fault severirty.
4 Take them to time Tech
5. Repair , stock
6. We repair
8. Send them for repairs
9. Repaired
10 look for specialists

11.O **ICT Policy**

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		
11.1 Does your school have an ICT policy?												
yes					1			1	1			3
no	1	1	1	1		1	1			1		7
11.2 If yes, Does the policy cover the folowing areas?												
1 Purpose for which ICT is intended in your school.					1			1	1			
2 Procurement /purchasing of computer hardware and software.					1			1	1			
3 Maintenance					1			1	1			
4 Security issues					1			1	1			
5 Insurance					1			1	1			
6 Replacement issues					1			1	1			
7 Rules guiding use by teachers					1			1	1			
8 Rules guiding use by pupils					1			1	1			
9 Other *(specify)*												

12.O **Sustainability**

12.1 Who pays for :

1 The phone bill for internet connection?

1.School 2.Donors 3. HCollege
5. Students through levies
6. School
9. School
10. School

2 Printing facilities?

2. School through SDA
3. Hcollege
4. The school
5. School - Departments as charged
6. School
8. School
9. School
10. School

12.2 Does the school charge students a computer Levy?

	A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		
yes	1	1			1		1	1	1	1		7
no			1	1		1						3

12.3 If yes What is it used for?

5. Maintenance, upgrading
6.Maitenance and lab upkeep
7. Servicing & buying material & parts for repairs
8. Acquire consumables
9. Maintenance + purchasing accessories
10. Puirchasing consumables and pay for internet

The End

6.2.3 Physics student (Appendix B3)

Physics Student- Results

		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Total
		BH	Sak	Hil	Htzl	Nyz	SAg	Sfa	Mar	Mag	Bon		
Type of school (p=private, m=mission		A	B	Cp	Cm	Cm	Cm	Cm	Cm	Cm	Cm		
School		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Total
1.1 Your e-mail address													
	Form 5	0	0	0	1	1	1	1	0	0	1		5
	Form 6	0	0	1	0	0	0	0	0	1	1		3
1.2 Type of school:													
	government group A (low density)	1											1
	government group B (high density)		1										1
	government rural												0
	mission school				1	1	1	1	1	1	1		7
	private school			1									1

2.O

2.1 Gender:		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Total
female	Form 5					1					1		2
	Form 6										1		1
male	Form 5	1	1	1	1		1	1	1	1			8
	Form 6	1	1	1	1	1	1	1	1	1			9
Total													20

2.3 How many are you in your physics class?

		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10		Av
Form 5	boys	13	11	10	24	11	17	14	12	15	gs		14
	girls	bs	2	3	3	2	1	0	0	1	9		2
	Total	13	13	13	27	13	18	14	12	16	9		15
Form 6	boys	15	17	11	13	9	19	13	16	10	gs		14
	girls	bs	3	2	3	0	2	0	0	0	6		2
	Total	15	20	13	16	9	21	13	16	10	6		14
Physics Enrolment		28	33	26	43	22	39	27	28	26	15		29

3.O Which of the following computer courses have you done?

		yes	
3.1	ICDL	///	3
3.2	Computer Literacy at school	~~////~~ ~~////~~ //	12
3.3	Computer short courses at private colleges	/	1
3.4	Other *(specify)* computer literacy at home	/	1
	computer studies at O-level	///	3

4.O What computer skills do you have? Rate yourself on the scale 0 to 3 .

0=nil, I do not know how to do this.
1=beginner, I can do this with some help.
2=confident, I can do this comfortably.
3=expert, I can even teach others how to do this.

		nil	begn	conf	expt
		0	1	2	3
4.1	**Core Skills**				
4.1.1	Using keyboard and mouse	1	2	9	8
4.2	**Word Processing**				
4.2.1	Creating, editing,formatting a word document	1	2	9	8
4.2.2	Drawing a diagram such as an electric circuit in *MSWord*	3	7	5	4
4.2.3	Drawing a diagram in a graphics program eg. *Paint*	3	6	6	5
4.3	**Spreadsheets (e.g. *MSExcel*)**				
4.3.1	Entering data	2	3	4	11
4.3.2	Using formulas for calculations	1	7	5	7
4.3.3	Creating graphs	4	6	5	5
4.4	**Multimedia**				
4.4.1	Opening a CD-ROM on a computer	5	6	5	5
4.4.2	Searching for information on a CD-ROM	6	4	5	5
4.5	**Internet**				
4.5.1	Sending and receiving e-mail	4	6	5	5
4.5.2	Searching the internet	3	6	6	6

5.O Do you have access to a computer at home?

yes	~~////~~ /	6
no	~~////~~ ~~////~~ ////	14

5.1 If yes, what do you normally do on the home computer?

S3.1Research for school assignments, music, internet
S3.2 Listen to music , record CDs, search the internet, Research for the information that I need.
S4.1 Since the home computer has no access to internet I normally spend my time on Ms word
S8.1 I normally play games, use word processors especially *MS word, explorer MS Access*
S9.2 Playing games, Typing assignments
S10.2 Checking mails on the internet and downloading journals

5.2 At school do you have access to a computer?

yes often	////	4
sometimes	~~////~~ ~~////~~ ////	14
never	//	2

5.3 Where else do you have access to a computer?

S1.1 My sister's workplace
S1.2 Internet café in town
S3.1 At my fathers business
S3.2
S4.1 Internet café's (public)
S4.2 My father's work place
S5.1 Nowhere else
S5.2 Intrnet café
S6.2 nowhwere else
S7.1 Family friends
S8.1 Nil
S9.2 Internet café
S10.1 At an internet café

6.O Has your physics teacher ever used a computer for teaching you physics?

Yes often		0
sometimes	///	3
never	### ###/ //##/	17

6.2 If your teacher has used a computer, can you provide examples of how the computer was used in your class and for which topics?

S2.1 We have no examples since our teachers do not use computers in physics.
S5.2 Electronics – used encarta as reference for electronic componentsand devices,
Fluids – finding practical applications of fluid mechanics
S7.2 Listened to CDs on quatum physics
We read about gravitation from stored documents
S9.2 Electricity and Magnetism, Electron flow, eledctromagnetic induction

7.O If your teacher has used a computer, what is different in class learning physics with computers compared to when computers are not used?

S2.1 We have not recognised the difference since our teachers do not use computers to teach physics
S5.2 The lesson becomes more exciting as we(students) view and get information directly
Lesson becomes short and precise
Teacher has no problems in trying to explain certain aspects.
S7.2 It is easier to understand concepts when a computer is used
S9.2 When using a computer one visualizes what really will be taking place in real life unlike in classroom lectures where no simulations can be obseved.

9.O Do you use the computer for physics learning outside the class times?

never	### ### ///	13
sometimes	###/ /	6
often	/	1

9.1 If you use the computer, descibe briefly what you do.

S2.2 Search for past examination papers
S3.1 Search for past examination papers and answer them
S3.2 Search for past examination papers.
S4.1 I do most of my research on the internet at café's since I find easy to understand on websites which are science related for example on a google search.
S4.2 I usually use it when studying forces in beams from a program I have and understanding atomic structure to visualise what an atom looks like when all the shells are in place
S5.1 There is an availble program called Encarta which provides vast information on various fields. I do some researches on certain topics for example gravitation that is for physics.
S5.2 use the internet and e- mail, play games
S9.2 Research and/or download information from the internet and stored programs

9.2 Roughly, how many of your classmates use computers in learning physics outside class time? ? Means I don't know

?		12
0		3
¼		3
½		0
¾		0
all		2

10.1 Have you ever used e-mail to communicate about physics?

yes	//	2
no	~~////~~ ~~////~~ //// ///	18

10.2 If yes, with whom?

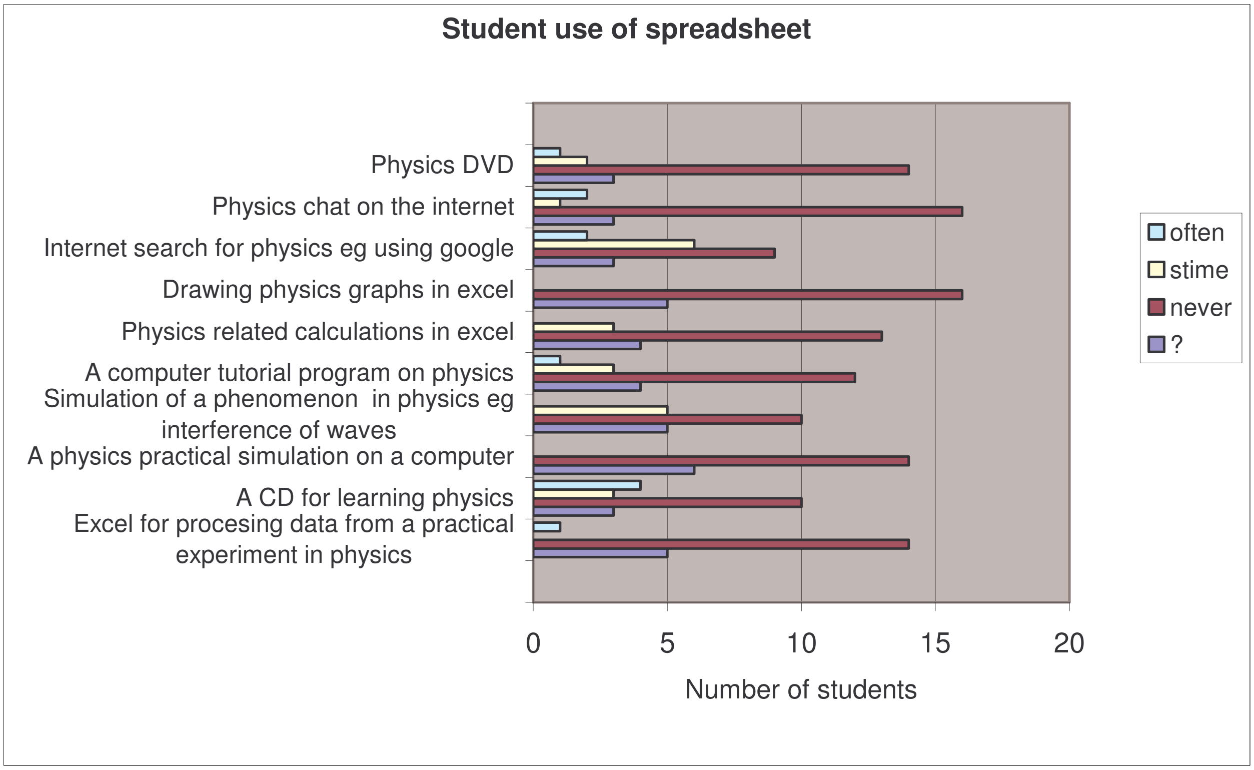
S4.1 With a friend of mine and father who is in the United Kingdom

11.O How often have you used the following?

stime=sometimes

?= I don't know this.

		?	never	stime	often
		0	1	2	3
11.1	Excel for procesing data from a practical experiment in physics	5	14	0	1
11.2	A CD for learning physics	3	10	3	4
11.3	A physics practical simulation on a computer	6	14	0	0
11.4	Simulation of a phenomenon in physics eg interference of waves	5	10	5	0
11.5	A computer tutorial program on physics	4	12	3	1
11.6	Physics related calculations in excel	4	13	3	0
11.7	Drawing physics graphs in excel	5	16	0	0
11.8	Internet search for physics eg using google	3	9	6	2
11.9	Physics chat on the internet	3	16	1	2
11.1o	Physics DVD	3	14	2	1



12.O Who do you turn to for help most often when you have a problem while using a computer in physics?

S2.2 No one since I have no access to a computer at the school
S4.1 My mother is veryinfluential in encouraging me to use the computer for physics and the one who guides me.
S5.2 Computer teacher and friends
S8.1 n/a
S9.2 my physics teacher

The End

6.3 Questionnaires (Appendix C)

6.3.1 Physics Teacher Questionnaire

A-Level Physics Teacher Qnaire No. [Official use only]

For the purpose of responding to the questions,
take ICT to mean computers and related software and peripheral devices.

1.O Name of school: ______________ Your first name ______________
Surname *(optional)* ______________

1.1 Your e-mail address *(If any)* ______________

tick

1.2 Type of school: government group A (low density) ☐ mission school ☐
government group B (high density) ☐ private school ☐
government rural ☐

1.3 Total A-level physics students ☐
Total Number of A-level teachers ☐

1.4 Please indicate your gender: male ☐ female ☐

1.5 Indicate your age goup 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60+ ☐

1.6 For how long have you been teaching A-level physics? ☐ years

2.O **The A-level Physics syllabus**

2.1 Which A-level physics syllabus are you currently following?

	yes	no
A-level Physics Cambridge 9244		
A-level Physics ZIMSEC 9188		

2.2 Did you teach syllabus 9244 before the switch over to 9188? ☐ ☐

2.3 Aim 5.3 of the Cambridge syllabus 9244 of 2000 stipulates use of Information Technology (IT) but the ZIMSEC syllabus dropped this aim. Do you think this omission was a good idea?

yes	no

2.4 Explain your choice.

____
____
____
____
____
____
____

3.O **Teacher Computer Competencies**

Computer skills that people have vary depending on what they use the computer for.
In this section you are given a list of some of these skills .

Skills rating key

0=nil. You do not have this skill.
1=beginner, you can manage but with some help. =begn
2= confident, you are able =conf
3=expert. You are proficient, very capable=expt

a. How do you rate yourself on the skills? Tick under (a)
b. Which of these skills do you use in A-level physics teaching? Tick under (b)

		a. rating				*b.*
		nil	begn	conf	expt	skills
3.1	**Word Processing**	0	1	2	3	I use
3.1.1	Inserting pictures, images ,diagrams into a document					
3.1.2	Saving a word document in other file formats eg html					
3.2	**Core skills**	0	1	2	3	I use
3.2.1	Creating and renaming folders					
3.2.2	Saving and finding saved files					
3.2.3	Connecting monitors, keyboards and mice to computers					
3.2.4	Connecting peripherals such as a data projector, camera, speakers to computers					
3.2.5	Scan for viruses					
3.3	**Graphics skills**	0	1	2	3	I use
3.3.1	Scanning an image or diagram from hardy copy					
3.3.2	Modifying images, diagrams to suit own need					
3.3.3	Creating diagrams using basic tools in a drawing program					
3.4	**Internet and e-mail skills**	0	1	2	3	I use
3.4.1	Accessing e-mail, making attachments					
3.4.2	Searching for information on the www					
3.4.3	Downloading webpages, saving webpages for offline use					
3.5	**Presentation skills**	0	1	2	3	I use
3.5.1	Creating a slide show eg in *MSPowerPoint*					
3.5.2	Inserting audio and video clips into a presentation					

3.6 Overall assessment

	For yourself			For your teaching		
How would you assess your ability to use ICTs for yourself in general and in your teaching of A-level physics?	B	C	E	B	C	E

B=beginner C= confident E=expert

4.O **Training /past experience**

Which of the following describe how you acquired the skills you already have?

		yes	no
4.1	Formal college/university as part of main course		
4.2	ICT literacy course at college/ university		
4.3	Self initiative at private college (part-time)		
4.4	ICDL course		
4.5	Teaching self on the job		
4.6	Workshops		
4.7	Other *(specify)*		

5.O In using ICT more often than not one needs assistance.
Who do you get help from?

		some-times	often	never
5.1	Computer teacher			
5.2	Another physics teacher			
5.3	Student in the physics class			
5.4	Other *(specify)*			

6.O **Access to ICT devices**

		yes	no
6.1	Do you have a computer at home?		

6.2 If yes, what do you use it for? ______________________________

____

____

____

6.3 At your school would you say you have access to computers for teaching A-level physics?

always	some times	Never

6.4 If never, why not? ______________________________

____

____

____

____

____

____

6.5 If you have access, what is the student computer ratio for your class? [ ] students per computer

6.6 What % of the computers are working all the time when you are using them? [ ]

		yes	no
6.7	Is there a computer in the physics lab preparation room?		

7.O **Teacher use of ICTs**
Will you please highlight some ways in which you have used computers and related ICT devices in the teaching and learning of A-level physics this year. It will be helpful if you can cite specific lesson topics or tasks your students performed and the computer resources used.

____

____

____

____

____

____

____

____

____

8.O **The presence and use of ICT artifacts**
Here is a list of ICT tools. Can you briefly describe in column (*a)* how you have used the technology in A-level physics teaching and learning? In column (b) indicate how often you have used the tool. Use the following key and tick the appropriate box.

0 =na (not available at the school)
?=ukn (unkown to you)
1=never
2=stime (sometimes, once or twice in the term)
3=often (more or less weekly in the term

			b. How often have you used the tool?				
		a. How have you used the tool?	na	ukn	never	stime	often
8.1	**Basic ICTartifacts**		0	?	1	2	3
8.1.1	Laptop						
8.1.2	Printer						
8.2	**Data Capturing devices**		0	?	1	2	3
8.2.1	Data loggers						
8.2.2	Scanner						
8.3	**Drives and storage**		0	?	1	2	3
8.3.1	CD-ROM						
8.3.2	CD-ROM writer						
8.3.3	DVD						
8.3.4	Flash memory (stick)						
8.4	**Multimedia**		0	?	1	2	3
8.4.1	Beamer /data projector						
8.4.2	Digital camera						
8.4.3	Large computer screen						
8.5	**Internet**		0	?	1	2	3
8.5.1	*Crocodile clips* program						
8.5.2	Physics java scripts						
8.5.3	e-mail						
8.6	**Software**		0	?	1	2	3
8.6.1	*MSWord*						
8.6.2	*MSPowerpoint*						
8.6.3	*Paint*						
8.6.4	Web authoring tools such as HTML, *Dreamweaver,* etc.						
8.6.5	Other *(specify)*						

9.O **Use of Spreadsheet**

In teaching /learning physics one may use data analysis software such spreadsheet programs. *MSExcel i*s one example.

Which spreadsheet functions do you currently use in A-level physics?

Tick in the box.

?=ukn (unknown to you)

1=never

2=stime (sometimes, once or twice in the term)

3=often (more or less weekly in the term)

		ukn	never	stime	often
		?	1	2	3
9.1.1	Spreadsheet formulas for calculations				
9.2.2	Spreadsheet function for sorting data				
9.1.2	Spreadsheet function for drawing graphs				
9.2.3	"What if function" for relationships between variables				
9.1.3	Spreadsheet formulas for modelling physics concepts				

9.2 How would you rate your spreadsheet skills?

nill	begn	conf	expt
0	1	2	3

9.3 Which of the following spreadsheet functions do your A-level physics students use in completing physics assignments?

Tick in the box.

?= I do not know if they use this

1=never

2=sometimes, once or twice in the term

3=often (more or less weekly in the term)

		?	1	2	3
9.3.1	Sum,divide,multiply,average formulas in physics calculations				
9.3.2	Rounding function				
9.3.3	Chart function for graphing data in physics practicals				

10.1 How would you rate the computer skills of your A-level physics students?

?=I don't know

?	poor	good	vgood
	1	2	3

10.2 What computer related courses do your A-level students attend?

____

11.O **Use of the Internet**

11.1 How often do you make use of the internet in the teaching and learning of A-level physics?

never	stime	often

11.2 What do you normally use the internet for? ______________________________

____

____

11.3 If you ticked *"never"* in 11.1, briefly say why not? ______________________________

____

____

12.O **Use of Computer simulations**

12.1 Have you used any simulations in A-level physics? yes ☐ no ☐

12.2 If you have, may you give some examples by name or title.

1 ______________________________

2 ______________________________

13.O **Use of Physics CDs**

13.1 Have you used any A-level physics CDs? yes ☐ no ☐

13.2 If you have, may you give examples by name or title.

1 ______________________________

2 ______________________________

14.O **Motivation**

14.1 What can you say is your strongest motivation in using ICTs in the teaching of A-level physics?

____

____

____

____

14.2 What are the challenges in using the ICT tools in the teaching of physics ?

____

____

____

____

15.O Give your honest opinion about use of ICT in physics teaching as expressed in the following statements

SD=strongly disagree D=disagree N=not sure
SA=strongly agree A=agree

		SD	D	N	A	SA
15.1	ICT is the "in thing" for teaching A-level physics					
15.2	One can afford to teach A-level physics without use of ICT.					
15.3	Bringing ICTs to the physics lab is a hassle					
15.4	ICT is a must for A level physics teaching and learning.					
15.5	The current A level syllabus is fine without mention of ICT.					
15.6	Use of ICT for physics teaching /learning should be made compulsory.					
15.7	If ICT is used in teaching A-level physics, it will be impossible to finish the syllabus.					
15.8	Use of ICT for teaching /learning is for developed countries.					

16.O **Your final word**

What is your word of encouragement or warning to those who woud like to use ICT in A Level physics teaching.

____

____

____

____

____

The End

If I am not availlable to collect the completed questionaire, please post using the return envelope suppllied.

6.3.2 Computer Specialist Questionnaire

Computer Specialist Qnaire No. [Official use only]

1.O Name of school: ____________ Your first name ____________
Surname *(optional)* ____________

1.1 Your e-mail address ____________

tick

1.2 Type of school: government group A (low density) ☐ mission school ☐
government group B (high density) ☐ private school ☐
government rural ☐

1.3 Total enrolment ☐
Total Number of teachers ☐ Total Number of Admin staff ☐

1.4 Please indicate your gender: male ☐ female ☐

1.5 Indicate your age goup 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60+ ☐

2.O What is your job title in the school? ____________

2.1 For how long have you held the post? ☐ years

2.2 What are your post school qualifications? ____________
____
____

2.3 How did you become a computer specialist? ____________
____

3.O **Infrastructure**
The following questions are meant to establish the ICT infrastructure at your school.
Fill in the boxes.

3.1 Computers :		Number
3.1.1	Number of computers at your school in total?	
3.2.2	Number of working computers in the school?	
3.3.3	Number of laptops?	

3.2 Location of computers:

3.2.1 Is there a computer in the school head's office? yes ☐ no ☐

3.2.2	How many computer laboratories are in the school?	
3.2.3	How many computers are in the school computer laboratory?	
3.2.4	How many are in the physics laboratory?	
3.2.5	Where else are computers located in your school?	
	1 ____________	
	2 ____________	

3.3 Devices

3.3.1 How many computers have the following devices?

1	CD-ROM drive	
2	CD writer	
3	DVD drive	
4	USB port	

3.3.2 How many of these peripheral devices are available?

1	Printers	
2	Scanners	
3	Digital cameras	
4	Beamers (data projector)	
5	MODEMs	
6	Flash memory sticks	

4.O **Network**

4.1 How many computers are connected on a Local Area Network (LAN)? ☐

4.2 What is the size of the switch /hub *(if any)* in use on the LAN? ____________

4.3 Which servers, if any, run on the LAN ? ____________

4.4 Are there any of the following physics teaching /learning resources shared on the local area network? ?=I don't know.

		?	yes	no
1	CDs on physics			
2	Physics java applets			
3	Physics assignments or homework			
4	Display of results of experiments, graphs by physics students			
5	Powerpoint presentations by the physics teacher			
6	Physics downloads from the internet			
7	Other *(specify)*			

5.O **Internet**

5.1 Do you have internet connection at the school?
If yes, answer questions 5.2 - 5.8 else go to 6.0.

yes	no

5.2 what type of connection is it? *Tick in the box.*

dial up	
leased line	
Other (specify)	

5.3 How do you rate the connectivity in terms of:

		very poor	poor	good	very good
1	getting a connection to the ISP?				
2	average speed downloading files?				

5.4 How many computers are linked to the internet? ☐

		yes	no
5.5	Do physics teachers have access to the internet?		
5.6	Do A-level physics pupils have access to the internet?		

5.7 Are you responsible for connecting users to the internet? ☐ ☐

5.8 If yes, have you had requests from the physics teachers for connection? for what purpose? ____________

6.O **Software**

6.1 How many of the computers run on:

MSWindows 95 /98 /ME	
MSWindows 2000 pro	
MSWindows XP	
MSWindows 2000 server	
Other (specify)	

6.2 What application programs run on the computers?

	yes	no
MSOffice 97/2000		
Open Ofifice		
Other (specify)		

6.3 Does the school have any CDs with physics related learning material?

yes	no

6.4 If yes, what are some of the CD titles availlable?

1 ______________________________
2 ______________________________
3 ______________________________

6.5 How often are the CDs used by:

1 The physics teachers? ________________________
2 A-level physics students? ________________________

7.O Computers in your school may or may not be used for the tasks that follow.
For each stated tick *yes* or *no* as applicable to your school.

		yes	no
7.1	**Curriculum: Computers in this school are used for;**	yes	no
7.1.1	Teaching school level Computer Studies (ZIMSEC A-level syllabus)		
7.1.2	Teaching school level Computer Studies (ZIMSEC O-level syllabus)		
7.1.3	Teaching school level computer Science (Cambridge syllabus)		
7.1.4	Teaching Vocational level computers for HEXCO examination		
7.1.5	Teaching ICDL		
7.1.6	Teaching computer literacy for all students		
7.1.7	Teaching computer literacy for A-level physics pupils		
7.1.8	Teaching computer literacy for teachers		

		yes	no
7.2	**Pedagogy: Computers in this school are;**	yes	no
7.2.1	Used by physics teachers as a tool for teaching physics		
7.2.2	Used by teachers as a tool for teaching Science subjects		
7.2.3	Used by teachers as a tool for teaching other subjects		
7.2.4	Used by physics teachers for internet searches for physics teaching resources		
7.2.5	Used by physics teachers for e-mail		

		yes	no
7.3	**Administration: Computers in this school are used for;**	yes	no
7.3.1	Typing exams		
7.3.2	Keeping records of students mark profiles		
7.3.3	E-mailing official documents		
7.3.4	Processing fees accounts		

8.O

8.1 Have you ever given help to the A-level physics teacher concerning ICT equipment used in teaching of physics?

yes	no

8.2 If yes, state the nature of help given. ________________________
____

8.3 How often have you done this? ________________________

9.O How many of the computers in your school were:

		Number
1	Purchased by the school?	
2	Donated by the President?	
3	Donated by an NGO?	
4	Other *(specfy)*	

10.O **Maintenance**

10.1 Who services the school computers? ______________________

10.2 What do you do with those that break down? ______________________

11.O **ICT Policy**

11.1 Does your school have an ICT policy document?

yes	no

11.2 If yes, Does the policy cover the folowing areas?

		yes	no
1	Purpose for which ICT is intended in your school.		
2	Procurement /purchasing of computer hardware and software.		
3	Maintenance		
4	Security issues		
5	Insurance		
6	Replacement issues		
7	Rules guiding use by teachers		
8	Rules guiding use by pupils		
9	Other *(specify)*		

12.O **Sustainability**

12.1 Who pays for :

1 The phone bill for internet connection? ______________________

2 Printing facilities? ______________________

12.2 Does the school charge students a computer levy?

yes	no

12.3 If yes What is it used for? ______________________

The End

If I am not availlable to collect the completed questionaire, please post using the return envelope suppllied.

6.3.3 Physics student Questionnaire

A-Level Physics Student Qnaire No. [Official use only]

1.O Name of school:____________ Your first name ____________
Surname____________

1.1 Your e-mail address ____________

1.2 Type of school: *tick*

government group A (low density)	☐	mission school ☐
government group B (high density)	☐	private school ☐
government rural	☐	

2.O

2.1 Please indicate your gender: male ☐ female ☐

2.2 What form are you in? Form 5 ☐ Form 6 ☐

2.3 How many are you in your physics class? girls ☐ boys ☐ total ☐

3.O Which of the following computer courses have you done?

Tick yes or no in the box.

		yes	no
3.1	ICDL		
3.2	Computer Literacy at school		
3.3	Computer short courses at private colleges		
3.4	Other *(specify)*		

4.O What computer skills do you have? Rate yourself on the scale 0 to 3 .

0=nil, I do not know how to do this.
1=beginner, I can do this with some help.
2=confident, I can do this comfortably.
3=expert, I can even teach others how to do this.

		nil	begn	conf	expt
4.1	**Core Skills**	0	1	2	3
4.1.1	Using keyboard and mouse				
4.2	**Word Processing**				
4.2.1	Creating, editing,formatting a word document				
4.2.2	Drawing a diagram such as an electric circuit in *MSWord*				
4.2.3	Drawing a diagram in a graphics program eg. *Paint*				
4.3	**Spreadsheets (e.g. *MSExcel*)**				
4.3.1	Entering data				
4.3.2	Using formulas for calculations				
4.3.3	Creating graphs				
4.4	**Multimedia**				
4.4.1	Opening a CD-ROM on a computer				
4.4.2	Searching for information on a CD-ROM				
4.5	**Internet**				
4.5.1	Sending and receiving e-mail				
4.5.2	Searching the internet				

5.O Do you have access to a computer at home?

yes	no

5.1 If yes, what do you normally do on the home computer?

____
____
____

5.2 At school do you have access to a computer?

tick

yes often	some times	never

5.3 Where else do you have access to a computer?

____

6.O Has your physics teacher ever used a computer for teaching you physics?

yes often	some times	never

6.2 If your teacher has used a computer, can you provide examples of how the computer was used in your class and for which topics?

1 ____
____
____

2 ____
____
____

3 ____
____
____

7.O If your teacher has used a computer, what is different in class learning physics with computers compared to when computers are not used?

____
____
____
____
____
____
____

9.O Do you use the computer for physics learning outside the class times?

never	some times	often

9.1 If you use the computer, descibe briefly what you do.

____
____
____
____
____

9.2 Roughly, how many of your classmates use computers in learning physics outside classtime?

?	0	¼	½	¾	all

? Means I don't know

		yes	no
10.O	Do you have an e-mail address?		
10.1	Have you ever used e-mail to communicate about physics?		

10.2 If yes, with whom? ______________________

11.O How often have you used the following?

stime=sometimes

?= I don't know this.

		?	never	stime	often
		0	1	2	3
11.1	Excel for procesing data from a practical experiment in physics				
11.2	A CD for learning physics				
11.3	A physics practical simulation on a computer				
11.4	Simulation of a phenomenon in physics eg interference of waves				
11.5	A computer tutorial program on physics				
11.6	Physics related calculations in excel				
11.7	Drawing physics graphs in excel				
11.8	Internet search for physics eg using google				
11.9	Physics chat on the internet				
11.1o	Physics DVD				

12.O Who do you turn to for help most often when you have a problem while using a computer in physics?

____

____

The End

If I am not availlable to collect the completed questionaire, please post using the return envelope suppllied.

6.3.4 Questionnaire Structure

Table 3.3 Questionnaire Structure for Physics Teacher

Question	Area covered	Number of sub questions		
		Closed	Open	Total
1	Demographic data	6		6
2	The A-Level Physics syllabus	3	1	4
3	Teacher computer competencies	6		6
4	Training /past experience	7		7
5	Collaboration	4		4
6	Access to ICT devices	5	2	7
7	Teacher use of ICT		1	1
8	The presence and use of ICT artefacts	6		6
9	Use of spreadsheet	3		3
10	Student skills	1	1	2
11	Use of Internet	1	2	3
12	Use of computer simulations	1	1	2
13	Use of Physics CDs	1	1	2
14	Motivation in using ICT		2	2
15	Opinion in use of ICT in Physics	8		8
16	Final comment		1	1
	Total	52	12	

Table 3.4 Questionnaire Structure for Computer Specialist

Question	Area covered	Number of sub questions		
		Closed	Open	Total
1	About the school	5		5
2	Personal details	1	2	3
3	Infra structure	9	1	10
4	Network	2	2	4
5	Internet	7	1	8
6	Software	3	2	5
7	Computer use	3	3	6
8	Collaboration with Physics teacher	1	2	3
9	Computer source	1		1
10	Maintenance		2	2
11	ICT Policy	2		2
12	Sustainability	1	2	3
	Total	35	17	

Table 3.5 Questionnaire Structure for Physics Student

Question	Area covered	Number of sub questions		
		Closed	Open	Total
1	About the school	2		2
2	Personal and class details	4		4
3	Computer background	1		1
4	Computer skills	5		5
5	Computer access	2	2	4
6	Teacher use of computers	1	1	2
7	Impact of use of computers by teacher		1	1
8				
9	Use of extra-school computers	2	1	3
10	Use of e-mail	2	1	
11	Use of ICT	10		10
12	Collaboration		1	1
	Total	29	7	

Cover letters (Appendix D)

6.3.2 The Provincial Education Director (PED)

RHODES UNIVERSITY Education Department

Letter to the Provincial Education Director

W.M. Mlambo
Mutare Teachers' College
Box 3293, Paulington, Zimbabwe

15 June 2006

Mr Muzawazi
Provincial Education Director
Mancaland
Mutare

Dear Mr Muzawazi,

Permission to undertake research at selected A-level schools in Manicaland

In fulfillment of my Master of Education (Information and Communication Technology) degree with Rhodes University, I am seeking your permission to carry out research at ten selected schools in Manicaland. My thesis focuses on the use of Information and Communication Technology (ICT) in the teaching and learning of A-Level physics. The respondents at each school would be one or two A-level physics teachers, a corresponding number of learners and a computer specialist.

With a number of computers that have found their way into your schools, through the President's initiative and other donors, I am sure you will be interested to know the extent to which schools are using the new technologies. Best practices will hopefully be identified and the experiences disseminated for the benefit of other schools.

The study is not concerned with the evaluation of any individual teacher, learner or the school. Information will therefore be presented in such a manner that confidentiality is maintained.

If you have any queries about the project, please feel free to contact my supervisor, Prof Cheryl Hodgkinson-Williams at Rhodes University. Her e-mail address is c.hodgkinson@ru.ac.za.

I thank you.

Watson Mlambo

6.3.3 The school Head

RHODES UNIVERSITY   Education Department

Letter to the School Head

W.M. Mlambo
Mutare Teachers' College
Box 3293, Paulington, Zimbabwe

15 June 2006

The Head
<>
<>
<>

Dear <>

Permission to undertake research at your school

In fulfillment of my Master of Education (Information and Communication Technology, ICT) degree with Rhodes University, I am seeking your permission to study the use of ICT in the teaching and learning of A-level physics at your school. Your school was selected as one of the ten A-level schools participating in the project in Manicaland. The respondents at your school would include one or two A-level physics teachers, a corresponding number of learners per teacher and the computer specialist. The research will include a survey questionnaire with a possible follow-up interview to clarify observations arising from the questionnaire.

The survey will be carried out at a convenient time during the month of July 2006. Responding to the questions should take about 20 minutes.

You may be assured that the study is not concerned with the evaluation of any individual teacher, learner or the school. To this effect no information provided by the individual will be presented in any way that could identify them or the school. The participants will be informed that they may withdraw from the process should they feel threatened in any way.

If you have any queries about the project, please feel free to contact my supervisor, Prof Cheryl Hodgkinson-Williams at Rhodes University. Her e-mail is c.hodgkinson@ru.ac.za.

I thank you.

Watson Mlambo

6.3.4 The Participant

RHODES UNIVERSITY Education Department

Cover Letter to the participant

W.M. Mlambo
Mutare Teachers' College
Box 3293, Paulington, Zimbabwe

15 June 2006

Dear Participant,

For my Master of Education (Information and Communication Technology) at Rhodes University, I am undertaking a study on the extent to which computers and the Internet are used in the teaching and learning of A-Level physics.

By virtue of being an A-level physics <teacher/ computer specialist /learner> you have qualified to participate in the case study at your school. Will you please take 20 minutes of your time to complete the questionnaire?

You may be assured that your responses will remain completely confidential. The survey is not concerned with the evaluation of you as an individual<teacher> or your school. No information you provide will be presented in any way that could identify you or the school. Information will therefore be presented in such a manner that confidentiality is maintained. I will however need your name and that of your school for the initial data analysis process in case I may need to contact you to clarify a response or to check the accuracy of my records. There after the names will be converted to codes or pseudonyms.

Should you feel threatened during the process you are free to withdraw without any repercussions. However in order that the results may accurately represent the situation in Manicaland it is critical that you give the questionnaire your best and most serious effort.

If you have any queries about the project, please feel free to contact my supervisor, Prof Cheryl Hodgkinson-Williams at Rhodes University. Her e-mail is c.hodgkinson@ru.ac.za.

I thank you.

Watson Mlambo

6.3.5 Permission from the PED

155/97

Reference: P/ Mlambo W.
E.C. No. 0228321 Z

Ministry of Education
P.O. Box 146
Mutare

3 August 2006

Mr W. Mlambo
Rhodes University
P.O. Box 94
Grahamstown 6140

To Whom It May Concern:

The bearer is a Rhodes University student. He has permission to do resarch in our schools. Please assist him.

MINISTRY OF EDUCATION
MANICALAND STAFF OFFICE
(CHIPINGE SECTION)
1 NOV 2006
P.O. BOX 146, MUTARE
ZIMBABWE

D. Chigudu
For Provincial Education Director Manicaland

6.4 Photo consent forms (Appendix E

6.4.1 Consent form CF1

CONSENT FORM

Project Title ICT in the teaching and learning of A-Level Physics in Manicaland: Multiple case studies

Researcher Mr. Watson Mlambo

I hereby give my consent for the above mentioned researcher to use the following photos that were taken during the course of this study in any academic publication.

I also give consent that photos that include students from my school can be used on the proviso that no learner can be individually recognised / identified.

Participating School ~~Head~~/Deputy/Representative Name MAKORE . S

Signed [signature] Date 06/11/2007

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date [signature] 06/11/07

6.4.2 Consent form CF2

CONSENT FORM

Project Title ICT in the teaching and learning of A-Level Physics in Manicaland: Multiple case studies

Researcher Mr. Watson Mlambo

I hereby give my consent for the above mentioned researcher to use the following photos that were taken during the course of this study in any academic publication.

I also give consent that photos that include students from my school can be used on the proviso that no learner can be individually recognised / identified.

Participating School Head/Deputy/Representative Name MR M CHAPUNGU

DEPUTY HEAD
MUTARE BOYS HIGH SCHOOL
2007
P.O. BOX 800 MUTARE
ZIMBABWE TEL 62301

Signed ______________ Date 06-11-07.

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date ______________ 6-11-07

6.4.3 Consent form CF3

CONSENT FORM

Project Title ICT in the teaching and learning of A-Level Physics in Manicaland: Multiple case studies

Researcher Mr. Watson Mlambo

I hereby give my consent for the above mentioned researcher to use the following photos that were taken during the course of this study in any academic publication.

I also give consent that photos that include students from my school can be used on the proviso that no learner can be individually recognised / identified.


Computer lab


Physics lab -notes


Physics lab -discussion

Participating School ~~Head~~/Deputy/Representative Name SILAS KAZIBONI

Signed [signature] date 08/11/07

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature [signature] date 8-11-07

6.4.4 Consent form CF4

CONSENT FORM

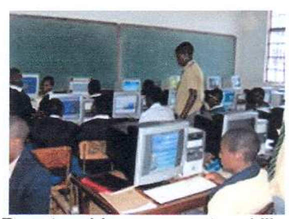
Project Title ICT in the teaching and learning of A-Level Physics in Manicaland: Multiple case studies

Researcher Mr. Watson Mlambo

I hereby give my consent for the above mentioned researcher to use the following photos that were taken during the course of this study in any academic publication.

I also give consent that photos that include students from my school can be used on the proviso that no learner can be individually recognised / identified.

Physics practical test



Peer teaching -computer skills

Participating School Head/Deputy/Representative Name GORBROKUPA Z. M.

Signed ____________ date 08/11/07

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature ____________ date 8-11-07

6.4.5 Consent form CF5

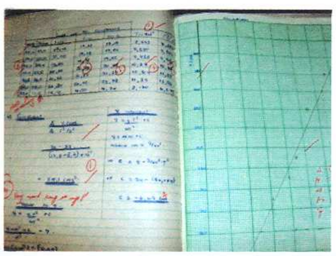
CONSENT FORM

Project Title ICT in the teaching and learning of A-Level Physics in Manicaland: Multiple case studies

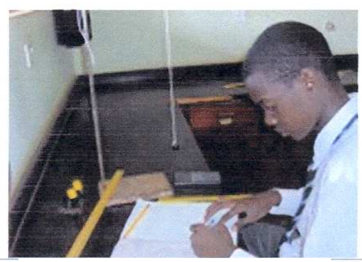
Researcher Mr. Watson Mlambo

I hereby give my consent for the above mentioned researcher to use the following photos that were taken during the course of this study in any academic publication.

I also give consent that photos that include students from my school can be used on the proviso that no learner can be individually recognised / identified.



Student's graph &



Physics practical session

Participating School Head/Deputy/Representative Name Batsirai

Signed ____________ date 8/11/07

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature ____________ date 8-11-07

6.4.6 Consent form CF6

CONSENT FORM

Project Title ICT in the teaching and learning of A-Level Physics in Manicaland: Multiple case studies

Researcher Mr. Watson Mlambo

I hereby give my consent for the above mentioned researcher to use the following photos that were taken during the course of this study in any academic publication.

I also give consent that photos that include students from my school can be used on the proviso that no learner can be individually recognised / identified.

Computer lab LAN

Physics lab

School entrance

Participating School Head/Deputy/Representative Name ________________________

Signed ______________________________ date ____________________

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature ____________________ date ____________

6.4.7 Consent form CF7

CONSENT FORM

Project Title ICT in the teaching and learning of A-Level Physics in Manicaland: Multiple case studies

Researcher Mr. Watson Mlambo

I hereby give my consent for the above mentioned researcher to use the following photos that were taken during the course of this study in any academic publication.

I also give consent that photos that include students from my school can be used on the proviso that no learner can be individually recognised / identified.

Senior Lab

Computer Science Students

Junior lab

Participating School Head/Deputy/Representative Name MATAMBANADZO F.J (EDUCATION SECRETARY)

Signed [signature] date 13-11-2007

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature [signature] date 13/11/07

6.4.8 Consent form CF8

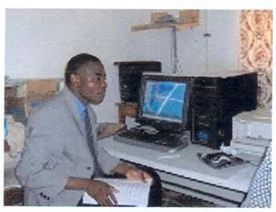
CONSENT FORM

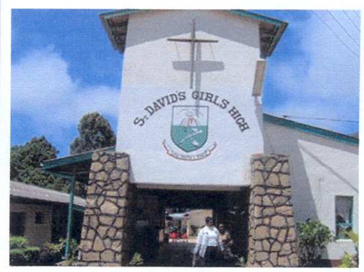
Project Title ICT in the teaching and learning of A-Level Physics in Manicaland: Multiple case studies

Researcher Mr. Watson Mlambo

I hereby give my consent for the above mentioned researcher to use the following photos that were taken during the course of this study in any academic publication.

I also give consent that photos that include students from my school can be used on the proviso that no learner can be individually recognised / identified.





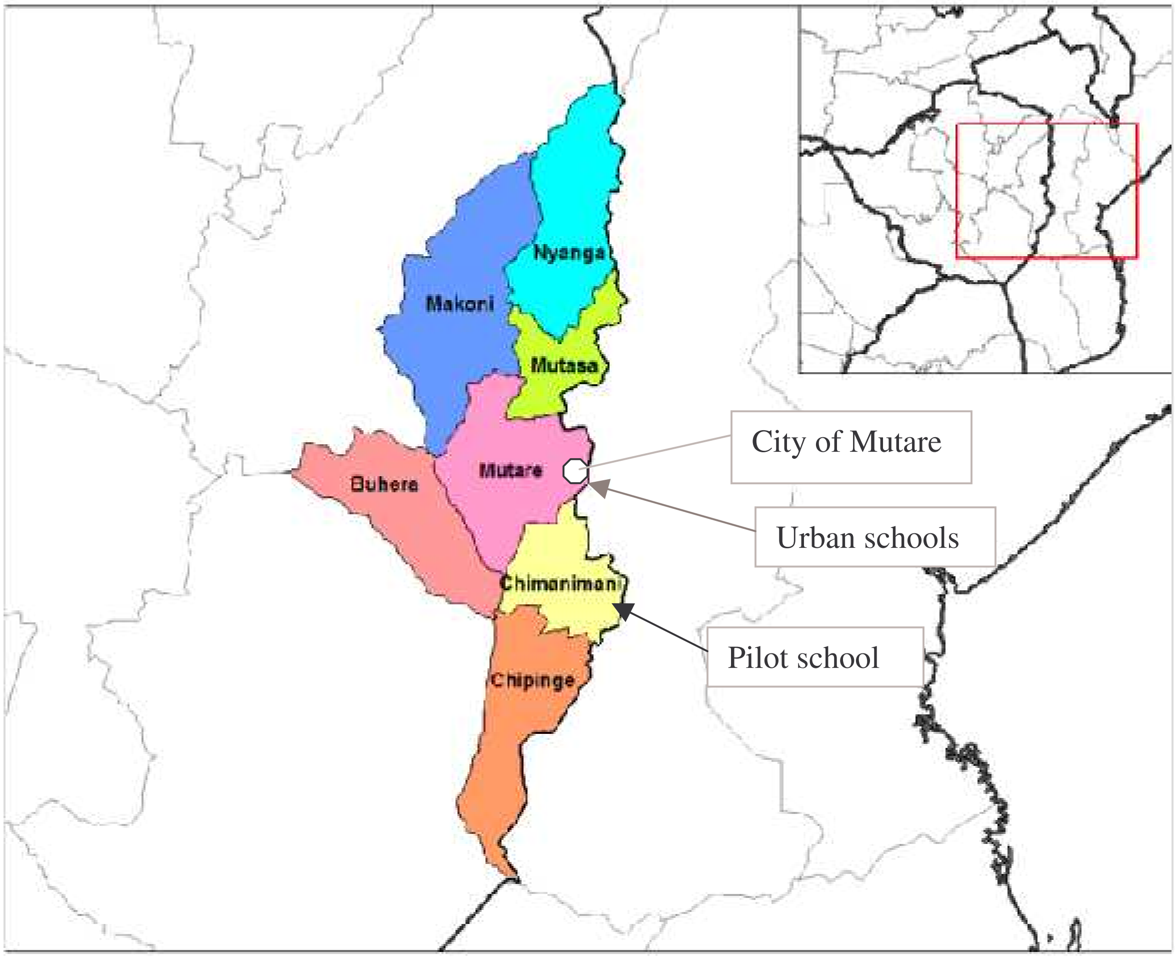
Participating School Head/Deputy/Representative Name MATAMBANADZO F.J (EDUCATION SECRETARY)

Signed ____________ date 13-11-2007

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature ____________ date 13/11/07

6.5 Map of Manicaland (Appendix F)



http://en.wikipedia.org/wiki/Manicaland /: date retrieved 16 June 2007

Group A and group B A-level schools are found in the city of Mutare.
Group C mission schools are spread through out the seven districts of the province.