CHAPTER 1

Introduction

Information and communication technology is increasingly becoming part of our everyday lives and is certainly a major aspect of organizational life. Much has been claimed for the contribution ICT can have upon the educational practices. Alexander (2000) highlights the powerful impact ICT can have on the teaching and learning process. Most researchers have concentrated on the generic learning processes and the findings indicate that levels of collaboration and communication can be enhanced by the skilled use of ICT.

Research suggests that information and communication technology (ICT) offers the potential to meet the learning needs of individual students, to promote equal opportunity, to offer learning material and also promote independence of learning among learners. For teachers, ICT is not only an essential tool, but it offers opportunities for professional development. It can also be used for linking and networking to other educational establishments. Larry Cuban (2001) is critical about the developments in the use of ICT in schools claiming that the overhead projector and video made little impact on teaching styles and so computers should not be treated differently. Computers are totally different from other technologies, because the internet can provide information about everything in the world and also enable unique forms of interactivity).

Profound changes to the learning process are also taking place. ICT can change the role of learners - as students as opposed receivers of information from the teacher in the classroom. Students can take responsibility for their own learning (student-centric approach). The teacher's role has changed from standing as an authority in front of the class to the one of managing and facilitating learning, moving around to different groups helping, suggesting, encouraging and learning along with the learners.

This research study sets out how information and communication technology has transformed the learning environment of Butterworth High School through the use of the digital technologies for some pupils so that the fixed (fixed or mobile) computers are totally integrated into the learning process. Timetable arrangements had to be

made to accommodate the learning process. With the kind of ICTs, learners and teachers utilized their knowledge networks to teach and train each other. Evidence suggests that knowledge has been transferred from all the participants. It is also evident that the effective use of ICT, and planned activities was embraced by all that were involved. This is partly due to the overwhelming desire of participants to concentrate on the creation of rich ICT environments.

The main challenge is to develop future teachers who know how to use the modern technology to improve student learning. Given the fact that most of the educators are computer illiterate, educators are required to understand the application of ICT within the education and training system. This further requires an understanding of the technology, its application to various learning areas and the ability to manage information and knowledge.

1.1. Computer literacy skills and curriculum knowledge

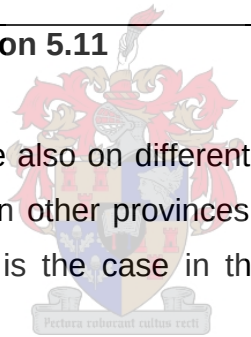
Information and communication technology is a vital catalyst for social change and economic development that is increasingly seen as an essential tool for developing countries. The South African government made strong declarations that information and communication technologies can change many aspects of human endeavor including the socio-economic development through out the world. President Thabo Mbeki highlighted the need to fight for the liberation against poverty, against underdevelopment, against marginalization and information and communication technology…..is a critical important tool in the struggle (Imbizo for African youth, 2001). James, T (2001) supported this argument saying ICT can be made relevant to the objective of poverty alleviation, not just through its effect on economic growth, but also by improving access to health care, education and other social services. According to Eraut, M (1991) the underprivileged will be affected if information and communication technology becomes a factor in *economic warfare*. Bialobrzeska and Cohen, (2005) have also stressed that ICTs are linked to social and economic development.

South Africa's status as one of the most developed economies in Africa is clear from the figures shown in Table 1 below:

Table 1: Personal computer and Internet users in selected countries in 2001

Country	**Personal computers per 1000 people**	**Number of Internet users (thousands)**
Angola	1.3	60
Ethiopia	1.1	25
Nigeria	6.8	115
Zimbabwe	12.1	100
South Africa	**68.5**	**3 068**
India	5.8	7 000
Brazil	62,9	8 000
United States	625	142 823
Japan	384,8	55 930
Germany	382.2	30 800
World	86,5	501 478

Source: World Bank 2003, section 5.11



The provinces in South Africa are also on different levels, for instance Gauteng and Western Cape are far ahead than other provinces. A higher number of households have a personal computer than is the case in the more rural provinces, such as Limpopo.

Table 2: Households with computers in South Africa

Province	Percentage of households with computers
Eastern Cape	4
Free State	4.9
Gauteng	15.1
KwaZulu Natal	7.1
Limpopo	2.2
Mpumalanga	4.7
Northern cape	7.1
North west	3.9
Western cape	18.2
South Africa	8.6

Source: Statistics SA (2003:97)

Integration of ICT in education has a major role to play in contributing to and transforming the social and economic development of this country. Critical elements that will determine the future of ICT as an effective tool for social and economic development have been determined namely:

- Cost
- Sustainability
- Utilization of ICT and
- Capacity building and
- effective support mechanism

Another important reason to use computers is to expand and reinforce student's computer literacy skills. Learners need to develop a comfortable familiarity with computer terminology and operations. Computers present a unique challenge because they require that teachers receive some degree of special training in order to operate them. Learning through the use of ICT is arguably one of the most powerful means of supporting learners to achieve the nationally –stated curriculum goals. In particular the use of ICTs for learning encourages learner-centered learning,

active, exploratory, inquiry -based learning, collaborative work among learners and teachers; and creativity, analytic skills, critical thinking and informed decision making.

Learners need to develop a comfortable familiarity with computer terminology and operations but they also need to know how to use ICT to access and use up to date subject specific knowledge, such as science in the 21st century).

1.2. National ICT Strategy in South Africa

South African government has established broad policies and strategies at national and provincial level in the use of ICT in education. A number of ICT frameworks for policies In South Africa, the use of ICT in education has been on policy agenda since 1995 and the possibility of using a range of ICT to find solutions received greater attention (James, T.2001). The Ministry and the Department of Education responded by initiating the Technology-Enhanced Learning Investigation (TELI) in order to establish a clear policy framework so that effective decisions about the use of ICT in education could be made. Key policy implementation agencies were formulated including the Centre for Educational Technology and Distance Education (CETDE) and SchoolNet SA, both evolved within the policy framework of TELI. James (2001) has highlighted the major areas of concern that have been discussed in African and international conferences namely: scarcity of ICT skills, training a broader base of ICT professionals, encouraging girls and women to use and produce ICTs, encourage the use of ICT to increase access to lifelong learning and increasing research capacity in ICT related policy. There are signs of dramatic changes in relation to the ICT access, infrastructure and costs within developing countries including South Africa. There is also a huge difference now in terms of telephone and cell phone access, with mobile infrastructures increasingly being used in more sophisticated ways.

Based on the challenges of using information and communication technology, information policies have to give priority to the development and retention, of valuable ICT skills, since more ICT skilled professionals come from other countries. Since ICT is capable of reducing obstacles, making it possible to use the potential of these technologies for the benefit of many people around the world.

South Africa is amongst the leading development countries in the adoption and diffusion of ICT, but it is slipping in terms of digital capability. Policies have been developed to create an environment that will allow for bridging the digital divide. The Department of Trade and Industry (DTI) came up with a five year plan with the following mission for the ICT sector: *Through the application and diffusion of digital technologies, South Africa will achieve considerably higher levels of social development and strong sustainable and equitable economic growth*. South Africa will be a catalyst in Africa and other developing countries by pioneering information and communication technologies suited to developing countries, and diffusing these products and services.

The DTI, in consultation with the Government departments, identified a number of factors that are critical to a successful ICT strategy such as:

- Developing human capacity: skills and knowledge.
- Cost effective and ubiquitous ICT network infrastructure.
- Sustainable growth of the domestic ICT industry.
- Rapid diffusion and adoption of ICTs through the economy.

Furthermore, a 5 year national e-Strategy for South Africa was developed by the Minister of Communications in consultation with members of the cabinet. The e-Strategy details plans and programmes that will address the development of a national e-transaction strategy, the promotion of universal access, e-readiness, etc. Telkom developed awareness programmes that were aimed at encouraging ICT use and promoting communication, education and the learning experiences through technology. South African youth was empowered to use the Internet to make electronic *pen pals* or *e – telpals* online on the e- telpal website. This strategy for ICT in education promotes basic computer literacy and compulsory training has been given at school level.

Infrastructure has been deployed in specially selected schools to manage the curriculum and empower school leavers to have a basic level of use in ICT. An education portal that will host a range of educational material has been created. Amongst the government initiatives, Khanya Project of the Western Cape was

established. The Department of Education delivered education in the classroom. As part of the government plan, Microsoft agreed to donate free software for all the countries' 32 000 government schools. The White Paper of e-Education (Department of Education, 2004) acknowledges the magnitude of the task of delivering ICT and the infrastructure required in schools.

The White Paper further proposes that the integration of the ICT should be spread out over three phases and be completed by 2013. In this plan all Education Departments in the country are to be empowered to use ICT for planning, management, communication and monitoring and evaluation. All schools are to have access to a networked facility for teaching and learning, and to high quality educational resources. All schools, teachers and learners will be confident and competent users of ICT and ICT will be integrated into teaching and learning. Communities will be involved in ICT developments at all schools**.**

In order to meet these targets, the government has a big challenge of providing ICT infrastructure to support and to ensure that the resources provided are used to the best of their advantage and in their particular context. It is advised that senior managers and school management teams should play a crucial role in ICT into the administration and teaching work of their schools.

There are high and ambitious visions for ICT in South Africa, but that the road to travel is a long one, not simply in terms of ICT infrastructure but in preparing and training teachers in the complex task of integrating ICT into the curriculum and classroom.

CHAPTER 2

RESEARCH STUDY AIMS, DESIGNS AND METHODS

2. Introduction

Leedy and Ormord (2001) argued that data and research methodology are inextricably interdependent. For that reason, the research to be used for a particular research problem must always take into account the nature of data that will be collected in the resolution of the problem. Furthermore, many kinds of data may be suitable only for a particular methodology and to some extent the data dictate the research method. According to Hughes (1980), methodology represents a corpus of procedures for analyzing social reality, which may then be codified into theory.

The process of research concerns not just method, but also the underlying methodology, philosophy of social research, in terms of which the basic assumption and criteria underlying research is framed Bailey (1982:32). Mouton and Mouton (2001) stated that the philosophy would include *a theory* of when and why to apply, for example qualitative rather than quantitative method, or vice versa and also an awareness of the limitations of various methods.

The research methodology that will be applied in this study will be based on a qualitative method, because this particular method seeks to describe the complexities of the human experience, be within or without the workplace. Qualitative research will be used to answer questions about the complex nature of phenomena with the purpose of describing and understanding the phenomena from the participants' point of view.

2.1. Research study aims and objectives.

This research study was carried out as part of a wider study commissioned by the Department for International Development, DEEP (the Digital Education Enhancement project). It has investigated:

(1) how information and communication technologies (ICT), effectively used, can significantly improve the teaching and learning of Science in one class at Butterworth primary schools, one of the twelve schools in the broader DEEP study as well as how knowledge can be transferred.

(2) the willingness of the teachers involved in the project to embrace the new approaches to subject teaching and learning, and teacher approaches to integrate effectively the use of ICT to support subject teaching.

This research seeks to extend the evidence base of how technologies can contribute to the Millennium Development goals of quality Universal Primary Education. The data was collected in order to consider effective uses of ICT and how classroom practices can be transformed.

The objectives of the DEEP research were:

- to identify the existing literature relevant to the use of ICT by teachers
- to investigate the effectiveness of the use of ICT- enhanced activities within Butterworth school including
- to identify the existing literature relevant to the use of ICT by teachers
- to investigate the effectiveness of the use of ICT- enhanced activities within the pilot schools
- to identify what the impact of ICT- enhanced teaching on student achievements and motivation is.
- to determine the impact of ICT use on the pedagogic knowledge and practice of teachers and communities in which they live and work is.
- to establish how teacher education and training can be developed to ensure teacher capacity to exploit the potential ICT

Some of these objects are fully explained in the DEEP report (2004).

- to investigate how ICTs (video conferencing) can enhance the transfer of knowledge.
- to identify how ICTs can empower educators on how to manage the challenges presented by the technologies.
- to determine the benefits and limitations of using the hand-held computer in a professional development context.

2.2 Research design and methods

Research methodology is largely discipline specific and varies widely even within some disciplines. According to Moser & Kalton (1977:87) a proposal must specify the research operations that will be undertaken and how results of these operations in terms of the central problem will be interpreted.

Research in library and information science is to a great extent quantitative in nature, but much insight can be gained through qualitative research. The most appropriate method that had been applied in this study is qualitative research. Qualitative research in education has gained wide acceptance and many researchers believed that all inquiry starts in a qualitative form (e.g. Lauer and Asher, 1988). Furthermore, qualitative research is designed to help us understand and describe the people and the social and cultural contexts within which they live.

Qualitative research focuses on phenomena that occur in natural setting, and they involve studying those phenomena in all their complexity (Leedy, P and Ormrod, J.E. 2001). Peshkin, (1993) supported this statement stating that qualitative research can reveal the nature of certain settings processes, relationships, systems or people, develop new concepts or theoretical perspectives about the phenomenon or discover the problem that exist within the phenomenon. Creswell, 1998, Guba & Lincoln, (1988) argued that there is no ultimate truth to be discovered instead there may be multiple perspectives held by different individuals and with each perspective having equal validity, but researchers would gain subject system knowledge and insight necessary to understand the anomalies being studied (Avison, D and Myers, M. D. 2002).

For all these reasons, qualitative methods seemed the best way to investigate in depth the experiences of learners and teachers in the school focused in the study. A review of the existing DEEP data and evidence from the literature on ICT and learning was also carried out.

This type of research allows for a broad range of insights into practice by drawing on as many sources of collecting data. Various approaches were earmarked for gathering as varied information and data sources a possible, including interviews, questionnaires, artifacts collection, participant observations, and researchers' impressions and reactions.

2.2.1. Butterworth Classroom Focus

The participant observation method was applied since the author of this article is currently employed as a teacher in the DEEP project school particularly focused in the research. The author is familiar with the pedagogical issues related to the application of ICT in schools. Notes were kept as Mouton; J (2001) suggested that researchers must keep notes as they participate in the fieldwork- often referred to as natural field setting. Classroom observations, interviews, diaries and questionnaires are other methodologies that were applied during this study. All these sources have been strategically used to gather information and data needed to explore the facts and reality about the effective use of ICT for teaching and learning.

2.2.2. Analysis of the broader deep data

This research also reviews data gathered during visits to all project schools by the research team. Educators, principals and community members were interviewed observed and questionnaires were administered to collect relevant information. A wide range of evidence is also available about the project outcomes on CD, tapes and also electronically. DEEP cluster meetings were organized to obtain more information on the issues highlighted in the DEEP report.

2.3. Literature review

A literature search such as academic journals, professional journals, Web government documents-e .g. BECTA, SchoolNet SA, White Paper on E-Education etc, was conducted.

2.3.1. THE DEEP study

The DEEP research study was aimed at the 24 teachers in 12 selected primary schools in Eastern Cape, South Africa. Participants were given support in their activities by the UFH and OU staff through training workshops and school visits that was planned throughout the years of operation. A range of multimedia resources, as well as a web environment was provided to offer the necessary support. Project implementation and investigation of the use of ICT related activities were studied through researcher observation, fieldwork and monitoring carried out by the partner institutions. Participants followed a specifically devised professional development programme to enable them to integrate and investigate a range of ICT –enhanced activities into teaching and learning of Science, Mathematics and Literacy.

This study focuses on those schools known to be using ICT effectively as a result of the project. Only 20 teachers of these teachers were contacted for this study, because two of the remaining four were not active and the other two were unavailable during the time of the study. The main focus of this study is on Science practice and outcomes within the broader DEEP project, since the author was mainly involved in the Science stream. The schools that were selected were chosen because they have improved the learning outcomes and changed their teaching methodologies and approach.

The discussions and findings of DEEP outcomes and activities are based on observation and data collected by a participant of the project.

2.3.2. Anticipated outcomes of the research project

The Deep project was established as an applied research project, providing a range of support for teachers; the following assumptions were derived from the research objectives and key questions:

- first, that student achievement and motivation can be enhanced by the effective use of ICT;
- second, that teacher's professional knowledge can, through training, be developed to ensure such improvements;
- third, that whilst due attention must be paid to national and local contexts, the global phenomena of ICT is creating cross national understanding about new ICT enhanced teacher approaches that can bring about improvements in teaching and learning.

2.3.3. Selection of schools and teachers

Schools were selectively sampled in line with criteria jointly drawn up by the project team and project advisers of the participating institutions. The DEEP project was announced over the radio and also during principal's meetings and educators was encouraged to apply. Educators were advised to find partners within their schools in order to qualify to be part of the project. Teachers interested in developing their teaching strategies had to apply to the University of Fort Hare. The copy of an application form is set out in Appendix 1.

The schools that were chosen in the Eastern Cape came from different backgrounds, some didn't have computers and some were computer literate and also different age groups were taken into consideration. The majority of the schools came from the most disadvantaged areas in the Eastern Cape. One third of the schools are from semi-urban settlements. To address the issue of gender, male and female educators were chosen although the majority was females. Prior educational and ICT experience was also regarded as an important aspect for selecting the schools.

The basic concept underlying all research is its design and methodology. Research design and methodology gives direction to the research study. The design of the

study concerns the plan to obtain appropriate data for investigating the research questions or hypothesis. On the other hand, research methodology concerns the various methods to be used in collecting the data needed. It arranges the data in logical relationships sets up means for refining the raw data and contrives an approach to analyze it.

An analysis of qualitative data collected will be done in chapter 4.

CHAPTER 3
LITERATURE REVIEW ON ICT FOR TEACHING AND LEARNING.

3. Introduction

A literature review of the effective use of ICT for teaching and learning was conducted. The theme that has emerged from this research is that the effective uses of ICT have been found in a range of research studies. A number of researches have been done on ICT and authors have commented upon the consequences of the increased use of technology- based learning environments. This paper draws on previous research reported by Leach, J and Power, T. Klaas, N and Mngqibisa, M. in (2002) ICT and the building of professional knowledge: experience in different African contexts, presented at the Pan- Commonwealth Forums on Open Learning, Durban, South Africa.

3.1. What is Information and Communication Technology (ICT)?

According to the White Paper on e-Education (2003) information and communication technologies (ICTs) represents the convergence of information technology and communication technology. ICTs are the combination of networks, hardware and software as well as the means of communication collaboration and engagement that enable the processing, management and exchange of data, information and knowledge in order to expand the range of human capabilities.

The stated definition of information and communication technology (ICT) represents a union of relationship between information technology (IT) and communication technology (CT). ICT definition provides a broader conception of ICT as it integrates traditional communication technologies and a new range of digital devices.

According to Duncan (1995) information technology (IT) is a term used to describe the items of equipment (hardware) and computer programme (software) that allow us to access, retrieve, store, organize, manipulate and present information by electronic means. Laptops, palm tops, scanners and digital cameras fit into the hardware category, whereas the database programme and multimedia programme fit into the

software category. Communication technology (CT) is a term used to describe telecommunications equipment through which information can be sought sent and accessed for example phones, faxes, modems and computers (Laudon and Laudon (2002).

Research showed that information and communication technology allows many people to generate and disseminate information, thus playing an active role in the process of interaction between professionals, laymen, learners, policy makers, peers etc. It requires skills, knowledge and access to resources to effectively do so.

A deductive definition that will be used in this study states that information and communication technology encompasses the range of hardware (portable computers, hand-held computers, digital cameras, video camera) software applications (CD-ROMs, multimedia resources, Encarta encyclopedias) and information systems (Intranet and Internet) available in Butterworth High school at the time of the research. The investigation will focus on how these forms of digital technologies were effectively used to enhance teaching and learning in science as well as to transfer knowledge.

3.2. Why choose portable computers in schools?

Loader emphasized that focus should be on developing a new curriculum that will be relevant in culture, that is being transformed by technology. Grasso (1993) supported extensive use of portable computers in changing the school curriculum and school culture. Research studies point to the potential of handheld technologies as learning tools (e.g. Fung, Hennessey and O'Shea, 1998, Hennessey, 2000, Soloway et al., 2001).

The type of software and hardware was selected according to the nature of the programme. A desired level of technology resources (hardware and software) must be provided in order to develop teacher's subject knowledge to support various activities and resources to support professional development. Loader, D (1993) Principal of the Methodist Ladies College was the first principal to introduce compulsory notebooks for students. Loader emphasized that focus should be on

developing a new curriculum that will be relevant in culture, that is being transformed by technology. Grasso, (1993) supported extensive use of portable computers in changing the school curriculum and school culture.

The educational benefits of handhelds over desktop computers include the following:

- Cost- affordable and educational discounts available for large quantities.
- Mobility- practically handhelds can be taken anywhere instead of being confined in one place (lab)
- Wireless- ability to transfer and share data and programs wirelessly overcomes the need for a more hardwired infrastructure.
- Size- in terms of physical storage, capacity to load large reference materials in portable format
- Ownership- The feeling of ownership encourages students to take care of the equipment
- Access- Many students can have access to these technologies
- Collaboration and sharing – beaming information from one computer to another
- Simplicity of use – teachers do not have to spend more time on teaching students how to use them

Furthermore, portable computers have potential concerns which will not be discussed in this paper due to size limitations. These concerns include:

- Compatibility
- Cheating
- Distraction
- Effectiveness/research
- Infrastructure
- Ownership
- Professional development
- Replacement issues
- Safety
- Screen readability

This kind of hardware necessitates forward planning by school mangers, teachers and learners. Based on the experiences of the project participants, planning is a very crucial aspect when integrating portable computers especially in classroom with big numbers. Working and handling this kind of portable technology, puts stress on the teachers as well as the school in terms of insurance. Insurance transit is to be organized by schools to secure these portable computers between home and school which is a greater risk.

In order to use portable computers effectively Marshall and Ruohonen (1998) suggested that electricity supply must be reliable so that batteries can be charged for use at school. Back-up batteries can also be provided to avoid losing information if batteries are not charged. In the South African context, electricity supply is a challenge for most of the disadvantaged schools. Although portable computers are not easily damaged because of the electric circuit that has no mechanical parts, screen abrasion or breakage has been a problem for portable computers (Gustafson, 1985). Provision should be made to ensure that portable computers are safe and secured. Special strong carrier bags are required to be used by teachers and learners to carry the portable computers

This section will look at how portable computers have transformed the Butterworth and other DEEP school set-ups into a community of learners, where cooperative and collaborative learning become the norm. Portable computers have allowed for greater access and greater flexibility than is generally available with desktop machines. This kind of hardware necessitates forward planning by teachers. Based on the experiences of the project participants, planning is a very crucial aspect when integrating portable computers especially in classroom with big numbers. Working and handling this kind of portable technology, also puts stress on the teachers as well as the school in terms of insurance.

Provision should be made to organize insurance transit between home and school which is a greater risk. Special strong carrier bags are required to be used by teachers and learners to carry the portable computers. Marshall and Ruohonen (1998) indicated that electricity supply must be reliable so that batteries can be charged for use at school. Although portable computers are not easily damaged

(Gustafson, 1985) because of the electric circuit that has no mechanical parts, screen abrasion or breakage has been a problem for portable computers.

3.3. What are the digital technologies that were used in the classroom?

According to Sharples (2000) information and communication technologies tools are becoming increasingly portable, flexible and powerful. In most schools, it is the principals and the administrators who make decisions about computer purchases. Teachers are limited to the equipment available and where it is placed in schools. Research literature (Gustafson, 1985) indicates that the majority of teachers uses the ICT resources available, rather than take the initiative of buying ones specifically relevant to their own subject. Professional and classroom activities are to an extent dictated by the available technologies or can be specially chosen to support such activity, and further recommendations made. The summary of the ICTs that were used by the DEEP teachers is available as appendix c.

Learners and educators could use all these information and communication technologies inside and outside the classrooms. They have displayed a number of benefits as well as limitations that will be discussed at a later stage.
Curriculum developers and policy makers should pay attention to a number of issues including: how to provide school level support, stress the role of district, provincial and national bodies in co-coordinating development of ICT and the importance of pedagogy. The following section will explore the view of pedagogy, knowledge and ICT.

3.4. Theoretical perspectives

This study will be informed by three design principles, namely:

3.4.1. Pedagogical content knowledge and practice

This section of the study will present a discussion of different pedagogical perspectives as indicated in literature review. Research has been conducted on ICT and pedagogy (teaching and learning) and a number of key findings have emerged. The evidence from the research literature showed that the realization of the potential

of ICTs will require significant changes in patterns of teaching and learning (Coburn, P et al 1982) and should not be confined to classroom practices, but an understanding of what pedagogy involves. Govier (1988) summarized research reporting that the insertion of a computer rarely affects either the curriculum or normal classroom practices: its use is assimilated to existing pedagogical assumptions.

Watkins and Mortimore (1999) in a review of research literature on pedagogy, asserts that the models of pedagogy have become more complex overtime, incorporating, recent developments in our understanding of cognition and meta-cognition. Alexander (1992) identifies teaching methods and pupil organization as the two facets of pedagogy. Leach and Moon (1999, pg 268) highlighted pedagogy in terms of several interrelated dimensions:

- educational goals and purpose;
- a view of learning;
- a view of knowledge;
- the learning and assessment activities required;
- the roles and relationships among learners and between the teacher and learner;
- the classroom discourse

It is very important for researchers to take note of the interrelated dimensions of pedagogy and how ICT can affect them. Shulman (1986) explained the transformations that teachers had to carry out to render their subject knowledge into an understandable form by learners. Banks et al (1999) extended Shulman's ideas by taking into consideration the multiple identities of teacher subject knowledge as subject expert (subject knowledge), subject teacher (school knowledge), teacher (pedagogical knowledge), and individual (personal construct). Teacher's knowledge of pedagogy consists of series of dimensions that govern the views; decisions and practice in the classroom (Banks et al, 1999). All models explained above prove the complexity of teacher pedagogical knowledge.

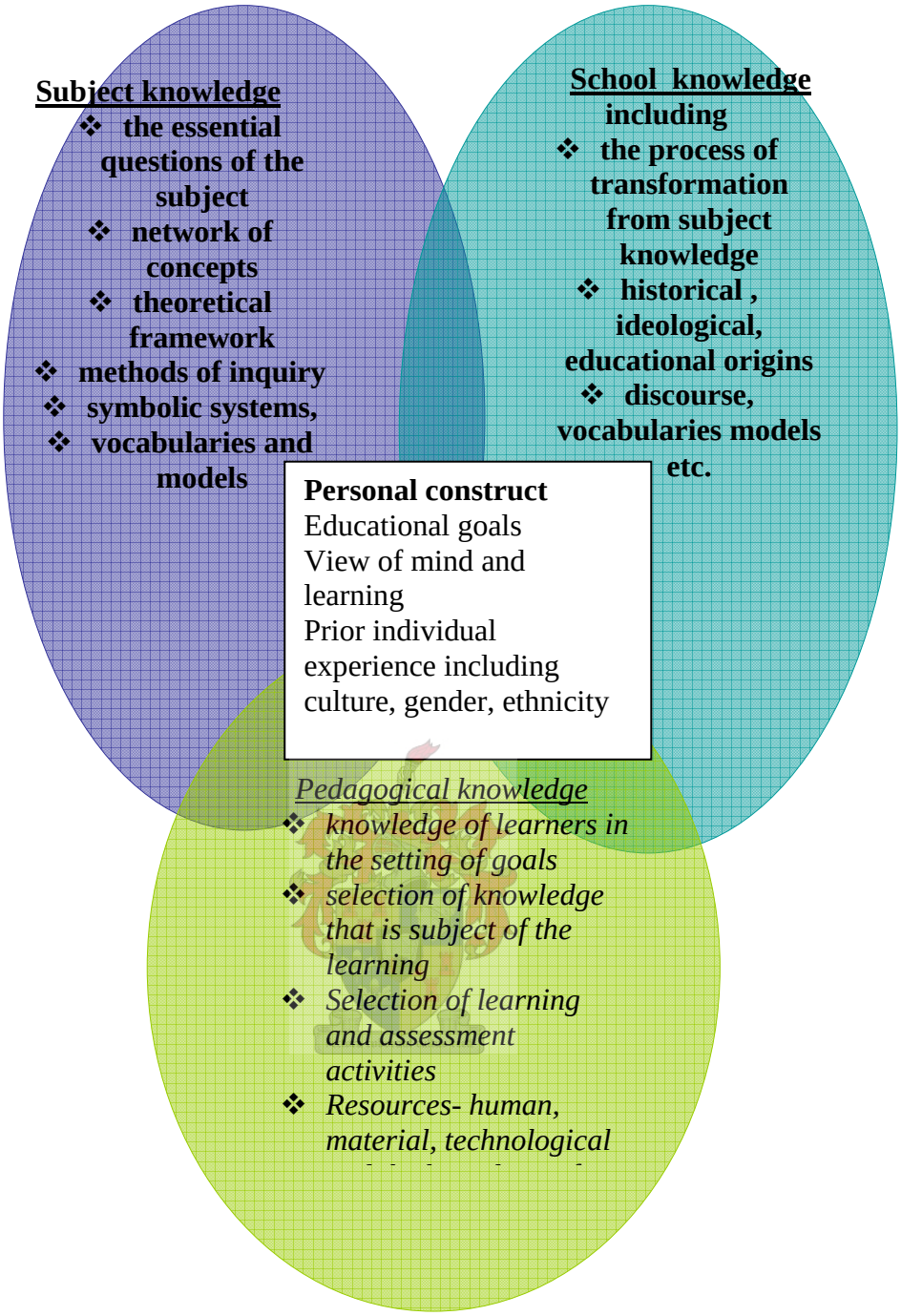


Fig.1. A model of teacher knowledge (Banks et al., 1999)

ICT integration will require significant changes in patterns of teaching and learning as well management of the school (Coburn, P et al 1982; Fullan M, 1993). Eraut, M (1991) further supported this statement stating that computers and information technology will have several effects on teaching methods and learning both because of the vast amount of data made available and because of the need for proper education in putting the information and intelligent use. The models of teacher pedagogical knowledge will make us understand the implications of introducing ICT

to schools and the kind of challenges that are faced by the participants. The personal identity in the model is a crucial aspect of showing the reactions of teachers towards the introduction of ICT within the project.

Teachers cannot develop their pedagogy without heed to the complex challenges of using ICT. Teachers wishing to support integration of ICT into subject teaching need to overcome the organizational and political, personal and professional obstacles that will develop (Loveless et al. 2001). Research literature showed that the implications for ICT in education is that pedagogical content knowledge differs between subjects and the choice of ICT resources will differ in terms of pedagogical practices for different subject teachers (Cox and Web, 2004).

Schulman's model included a range of pedagogical reasoning skills which are listed below:

- Comprehension –examining the content to be taught and considering its inter-relationships with other subjects
- Transformation- transforming ideas of knowledge
- Preparation- preparing the curriculum in relation to aims and objectives
- Representation- thinking of ways that the ideas and skills may be made accessible to pupils
- Adaptation- fitting the material to the characteristics of the pupils taking into account of age, gender, culture etc.
- Tailoring- fitting the curriculum and teaching plans to a specific group of pupils
- Instruction- performing a variety of teaching and class management activities
- Evaluation- assessing the effectiveness of the teaching through the assessment of pupils as well as other types of evaluation.

McCormick (1992) suggested that there is a need for clearer thinking about the nature of change in relation to the use of ICT. Moseley et al. (1999) supported this argument stating that teachers must be engaged in discussions focused on the dimensions of pedagogy so as to encourage them to clarify their views and to re-examine them in the light of the use of ICT as did (Leach and Power, 2005) with the DEEP participants. Grossman (1990) concluded by saying knowledge is an overarching conception of how to teach a particular subject.

3.4.2. Classroom as a community of practice

Secondly emphasis will be on classroom as a *community of practice (COP)*. This builds on Woolgar's (1988) idea of scientific discovery occurring at the workbench. According his view, workbench refers to communities that involve small groups of individuals who work closely together in ongoing collaboration to solve problems of immediate and joint concern**.** Newell, S, et al (2002) referred to these communities, as communities which are not based on interest and geographical area, but rather on communities based on practice, hence the name communities of practice. George Pór (1985) described communities of practice as *connecting islands of knowledge into self organizing, knowledge sharing networks*. Draft and Palus (1994:11) presented a set of communities of practice of shared activity, shared knowledge and shared ways of knowing.

Brown and Duguid (1998) defined these communities by differentiating between the *know-what* and the *know-how* and further explained that the know-how include the ability to put the know-what into practice and that can be found among groups engaged cooperatively in the same work practices. Communities of practice support the work process directly by allowing individuals to share experience about work and thus understand it better. These small groups would be characterized by small collaborative groups, and in our case the learners, teachers and researchers who supported the growth of the community through the programme lifespan. The major role of the community is to be highly interactive and independent, working together to use and evaluate the impact of ICT tools at disposal.

DiBella and Nevis (1988) identified three essential features of organizational learning which included the following:

- New skills, attitudes, values and behaviors are created or acquired over time
- What is learned becomes the property of some collective unit
- What is learned remains within the organization or group even when individuals leave.

Based on these features, communities of practice are seen as a vital ingredient in the acquisition and sharing of learning-making knowledge a collective resource for an

organization, rather than the property of a particular individual. Skyrme (1999) suggested that the most powerful communities are those that are customer or problem focused. Literature review showed that it is difficult to manage the communities of practice as they are only responsible to themselves and open-ended. That statements indicated that communities of practice need to be cultivated, rather than controlled (Newell, S et al; 2002)

Wenger (2002) suggested various ways of cultivating the communities of practice, such as

- Events
- Leadership
- Connectivity
- Membership
- Learning projects
- Artifacts.

All these ways were demonstrated by the DEEP programme in many ways such as: Events- project was launched in the presence of the Minister of Education and other stake holders. At completion of phase 1 of the project affirmation event was organized. Participating schools had to show case their activities and reflect on the experiences. DEEP schools were divided into clusters according to the geographical distribution of schools. Project partners emerged as strong teacher leaders. Some ways of communities of practice are available in the DEEP report (2004).

Lastly, information and communication technology played a major role in linking together different communities of practice that are geographically dispersed. More details will be provided in the next chapter, under *findings and discussions*.

3.4.3. Collaboration

This section will look at how portable computers have transformed school set-up into a community of learners and teachers, where cooperative and collaborative learning became the norm.

Paloff and Pratt (1999) discussed the process of learning as *community building* and offered a number of core elements which are crucial to the school. Collaborative learning is regarded as one of the key elements. According to Wood and Gray (1991) collaboration occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process using shared rules, norms and structures, to act or decide on issues related to that domain. Ewing and Miller (2002) stated that at it's simplest level, collaboration may be simply sharing information with another person, department or organization…at it's most advanced level collaboration involve unifying communication processes and content and establishing forums for accessing resources and building content and value together.

Collaborative learning should be seen as a social process where community members share and learn from each other. Lave and Wegner (1991) and Rogoff (1999) highlighted that there is a need to understand the roles, responsibilities of the community members as they collaborate with the knowledgeable others. Burgoyne and Reynolds (1997) also viewed learning as social construction whereby the communities collectively construct new social meanings and realities.

Collaborative learning involves a number of possibilities such as formal and informal networking to share ideas, information and experience. In the information society, no one organization knows everything it needs to know …. collaboration creates a process for sharing information between interested parties so that both benefit by having a more global understanding of issues and concerns (Butler and Coleman, 2003)

Collaboration also raises a wide variety of issues- technical, pedagogical, industrial, financial and strategic. Robinson et al., (1998) raised issues concerning collaboration

e.g. peer- collaboration. He argued that collaboration depends heavily on close corporation between academic and support staff involved.

Butler and Coleman (2003) determined five (5) models of collaboration such as:

- Library
- Solicitation
- Team
- Community
- Process support

They suggest that these models can be used simultaneously, yet separately or combined into hybrid models e.g. combining team and community, library and solicitation. A framework for analyzing and designing collaborative systems can be built based on an understanding of pure models and how they can be combined. Community is a less common model of collaboration, but extremely powerful, used to facilitate the activities of a community such as community of practice (CoP) (Butler and Coleman, 2003). Community of practice and collaboration share a number of characteristics such as those mentioned in 3.4 of chapter 3. Fullan, Bennet and Mc Laughlin (1994) indicated that teachers need to break through the traditional isolation and start collaboration and give feedback to themselves with the ICT developments.

Observations on classroom transformations should be aimed at teacher practices as well as learners. It is crucial to highlight that students cannot be continuous learners without teachers having the same characteristics (Sarason, 1990). To support this statement, teachers should regard themselves as learners and if learners are to succeed, teachers must also succeed (Fullan, 1993).

Teachers and learners should apply the best model of collaboration that would enable them to share and develop pedagogical knowledge through the use of ICT. Furthermore, if knowledge represented in new forms is to be gained, then a classroom community set within a wider professional and academic constellation would appear to offer more in terms of knowledge validation, dissemination and utilization.

3.5. Knowledge management tools for collaboration.

Eraut, M (1991) indicated that video conferencing is a way which could enable geographically isolated people to communicate in groups, share and transfer knowledge from each other. Video conferencing is an essential tool for knowledge networks commonly used by many organizations for scheduled meetings, ad hoc discussions when visual contact is helpful (Skyrme, D.J, 1999). Referring back to chapter 3, Wenger (2000) relates to the need to communicate in communities of practice, *as essential to learning* and at the very core of what makes building blocks of social learning and are means by which we define competence through an experience of direct participation. Video conference was seen as a professional platform and tool for promoting social integration and other interactive processes in educational system. Videoconferencing must also be seen as a way of linking two or more sites by video and enables people at each site to interact as if they were in one site.

Video conferencing is straightforward but it is also important to take some important guidelines into consideration e.g.

- For study centre conferences, planning ahead is very crucial and checking the availability of venue and time restrictions as it [centre] might be used by other groups
- Familiarize participants with the camera operations, adjust camera to change the view and add interest, zoom in on relevant speaker
- Be aware of technological limitations: use the mute button to cut out the background noise while others are speaking
- Make yourself video friendly by wearing pastel coloured clothes and look at the camera when speaking, avoid rapid movements. Be natural, pause frequently and speak slowly.

Many studies showed that students react positively to video conferencing, finding it enjoyable and showing considerable interest in the medium (Wright & Whitehead, 1998; Eales et al. 1999). Research literature showed some benefits of video conferencing for both learners and the teachers namely:

- democratic medium which allows authentic communication between participants from different cultural backgrounds developed multicultural relationships and understanding, while enriching traditional activities (Cifuentes & Murphy, 2000)
- It allows communication which takes place independently of time and place
- Deep participating teachers used the video conferencing to discuss the future of the project, plan activities together, and promote communication between learners form the two countries.
- It provides enhanced opportunities for language students to interact with native speakers (Kinginger, 1998, Wright & Whitehead, 1998).
- Video conference enables learners to be disciplined and be tolerant of each other, take turns when speaking (Thorpe, 1998)
- Teachers and learners overcome the feeling of isolation and develop social skills by associating with peers who have similar needs. Video conference context acts as a focus for some learners, helping them to organize the way they think and act.

Cifuentes and Murphy (2000) indicated that video conferencing have raised the academic aspirations of teachers, as their learners discuss with more *assured* students, who become positive role models.

Video conferencing, as a knowledge management tool is becoming popular and more links need to be developed to enhance teaching and learning as well as the transfer of knowledge. Learners and teachers need to be empowered to use these technologies so that they can cope with the challenges of the knowledge era.

3.6. Integration of Information and Communication Technology into the curriculum.

ICT has great potential for enhancing teaching and learning aims, objectives and outcomes. The realization of the potential of ICT relies heavily on how ICT is integrated in the curriculum. Much attention should be spent on issues of pedagogy. A variety of approaches have been used to analyze and support the integration of ICT into school curriculum. There is bulk evidence that the approaches that focused on the computer-learner interactions, deal with teaching and learning issues. The use of ICT has become integral to a range of learning activities and therefore further

analysis should explore a variety of software and hardware used in schools in terms of how knowledge, the learner, the relationships with other learners and the role of the teacher is viewed in terms of the ICT application (Scrimshaw, 1997). Further analysis to reflect on the contemporary views of learning, knowledge and pedagogy should be extended (Edwards & Macier, 1987; Leach and Moon, 1999; McCormick & Paechter, 1999, Murphy, 1999, Mc McCormick and Murphy, 2000).

McCormick & Scrimshaw (1999) defined these contemporary views as social constructivist and situated perspectives; emphasize the social aspects of learning through ideas such as participation in communities and the social construction of knowledge. Based on this view learners are seen creating identities by learning to participate in communities of practice. Knowledge is therefore seen as a social process of knowledge construction. Prusak, L. (1997) supported this statement saying that knowledge of a firm must be understood as socially constructed, or more simple stated as resting in the organizing of human resources.

Knowledge depends on the interaction of people for its development (Nonaka and Takeuchi, 1995; Von Krogh and Roos, 1995). Learners' share and gain knowledge through participating in social activities and that meaning is created. Learning process should therefore be viewed as an engagement in culturally authentic activity, participation in community of practice. It has become evident from this perspective that there is close relationship between views of learning, knowledge and pedagogy. ICT integration needs to respond to the increasingly sophisticated views of learning as well as to respond to the way in which national curricula are being implemented. Glacier, (1984, 1992) highlighted that contemporary views of learning and knowledge that indicated the importance of domains, whether subject or areas of human activity.

Integration and use of ICT into the school affects curricular activities in diverse ways. Most of the DEEP project schools used IT to expand their existing subjects. One school extended their curriculum because of the impact of the ICT on the school as a whole. Computer applied Technology has been introduced. ICT implementation in schools is a complete process, involving many factors (Pelgrum & Anderson, 1999, Venezky & Davis, 2002). The question about the extent to which ICT implementation

has modified schools' structure and functioning has been controversial over the years (Cuban, 1986, Schank & Yone, 1991).

When integrating ICT into the curriculum one need to understand that integration is a complex, multifaceted process, which cannot be achieved overnight. Meaningful curriculum integration can be supported or constrained by many factors within the school environment. These factors will be discussed more in detail in 3.8

3.7. Teaching Science using ICT

There is a long history of using computers for teaching of Science and in other disciplines to both primary and secondary school pupils. Over the last decade there has been an explosive growth in the range, sophistication, penetration rate and potential implications. This is partly due to the rapid rise in computer power and fall in computer costs and particularly since the emergence of Internet.

Goodson and Mangan (1995) found evidence of reshuffling cards, but little evidence of evidence of everybody trying to play the game.(Teark in press: 11) detected few signs of radical change to existing structures and working practices or even evidence of particularly innovative application of ICT. (Cuban; 2001) extended this argument stating that classroom teachers are simply using the ICT to do what they have always done although claim they have changed their practice. One possible reason is that classroom teachers have historically little say in designing and implementing development plans for using ICT within their schools and for defining its role within the subject curricula.

Contrary to that, Cox et al., (2004) indicated that many teachers are integrating ICT into Science teaching in a way that motivates pupils and enriches learning or stimulates higher level thinking and reasoning. As other studies have discovered, these teachers tend to be those with an innovative pedagogical outlook.

Kerr's (1991) interview and observations with American teachers who had successfully incorporated technology into their practice indicated that using it allowed obvious and dramatic changes in classroom organization and management. However

technology should not be viewed as the driving force in teachers thinking and practice. Macfarlane and Brown (2001) highlighted the need to change the classroom context as a prerequisite to enhanced ICT use. Technology was serving as a lever through which teachers seek to make established practice more effectively technology appears also as a *fulcrum* for some degree of orientation of practice (Hennessy et al.; 2003). Thus, some teachers changed their ideas about their role and authority in the classroom and others recognized the need for new teaching approaches and skills such as information literacy.

A second issue arising across a number of design initiatives is the importance and continuation of a strong teacher role. John and Sutherland (2004) stated that the teachers' role is enviably connected to the epistemological orientations and personal theories of each teacher, however such roles interpolate with established school subject subcultures to create a particular pedagogical style.

According to Noss and Hayles (1996) ICT offers new ways to express and make visible key relationships and structures within the subject matter. Selinger (2001) indicated that once teachers' expertise with the technology is balanced with the subject teaching, they may show increased levels of motivation and use regarding ICT. According to Beare and Slaughter (1993), creating and sustaining curriculum changes and innovations is partly a matter of confidence. The change in confidence and attitude has been one of the most striking consequences of the ICT use. It is argued that the ICT convergence is capable of equipping teachers to promote creativity, interpretation and expression in their pupils. Cooper, B and Brna, P. (Vol 2/3 2003) stated that the motivation of the children seemed to involve emotional *feel-good* factor as they would express freely the way they enjoy working with ICTs.

Ball (2003) categorizes four ways in which ICT can be used in primary Science:

- As a tool
- As a reference source
- As a means of communication and,
- As a means for collaboration.

Evidence of how ICT was used by DEEP learners will be discussed in Chapter 4 under findings.

ICT for Science can support both the investigative (skills and attitudes) and more knowledge based aspects (concepts) of primary Science. Furthermore, ICT can enhance the opportunities for children to engage in effective communication at several times. Murphy, Beggs and Carlisle (2003) reported that increasing the amount of practical investigative work in Science particularly when children are using ICT, had a marked positive effect on their enjoyment of Science. Ausubel (1968) argued that the most important single factor influencing learning is what the learner already knows. This model of learning predicts that active learning such as that promoted by constructivist teaching approaches in which children are engaged in knowledge construction enables more pervasive neural connectivity and hence enhanced science learning.

Other research into children's learning in Science being carried out in the last decade has focused on the role of the primary teacher. Many findings e.g. Harlen (1995) have pointed towards problems linked to primary teachers' insufficient scientific knowledge background and their lack of confidence in teaching science. Some studies have criticized the level of the content of some areas of primary science.

Successful integration of ICT depends on the development of an appropriate pedagogy- which is best begun with incorporation and adaptation within teachers' conventional practice, and then going beyond it. It is only if ICT can provide activities with a clear and concrete curriculum focus which support and enhance learning will its use be initially adopted and integrated into departmental schemes of work and all teachers' lessons.

3.8.1. Teacher training and professional development

Information Technology is the basis of the knowledge economy. Everybody will need skills in information technology to transact business and to work in the future… teachers will also be transformed. Teachers need mastery of and access to Information and Communication Technology to manage the learning of their students

(Queensland State Education 2010:6). Six ICT drivers are identified as providing the necessary conditions for successful learning with ICTs.

1. Learning - teaching and the curriculum – integrating ICTs into subject and curriculum areas.
2. Learning and development inspiring teachers have the necessary capabilities to effectively engage with and use ICTs as a tool for learning.
3. ICT infrastructure – ensuring teachers and students have access to modern ICTs.
4. Connectivity – making connections with the people, data, information required to learn connecting to each other and to the internet.
5. ICT support initializing innovative support measures to remove some of the burden from teachers so that they can concentrate on the core business of teaching and learning.
6. Innovation – acknowledging and encouraging school and teachers to rest on their laurels but to commit to improvement.

3.8.2. Support for ICT teacher professional development

Teacher professional development in ICT for teachers is stressed world-wide, and equal emphasis needs to be placed on administrative training for knowledge management, teamwork, community relations and creating a culture of innovation and of mistakes. Weets, (1997) viewed teacher training and development as a main critical success factor in deploying ICT in education. Ongoing teacher training and support is critical to the successful utilization and integration of ICTs and also seen as key to successful usage of ICT in education.

Research indicates that teacher professional development should be seen as a process, not an event. This means ongoing teacher professional development activities are highly effective as compared to discreet, *once off* training events.

Gustafson (1985) suggests that teachers and administrators should be fully equipped to be proficient. In other words, they must be trained to understand how to modify ICT to accommodate existing needs and how to use it intelligently.

Gustafson (1985) identified a list of key factors that are seen to be critical for ICT teacher training and development programme.

- Incentives and support for teacher training programme
- Teacher- directed training
- Adequate access to technology
- Community partnerships
- On-going informal support and training opportunities

In order to keep pace with ICT skill demands, brought about by the fast rate of change in technology, it is very important to train staff continuously. Teachers must keep up with the latest developments in ICT. Computer based training and audio based training could provide a more flexible method of keeping up to date with packaged software. Marshall and Ruohonen (1998) suggested that social inequalities need to be taken into consideration in arriving at standards for sound education and training practices.

It has become abundantly clear that the training of teachers in ICT skills and appropriate pedagogical approaches is essential. Professional development should therefore, include methods for evaluating and modifying pedagogical practices and expose teachers to a variety of assessment methods. Eraut, M (1991) supports the need for training because appropriate pedagogical expertise is scarce in teacher training institutions and it is difficult to find appropriate school experience for training teachers. The skills required by teachers in using computers should be seen as predominantly pedagogical rather than technical (SED, 1987). That necessitates training and development of educators as well as retention of the existing skilled or qualified teacher/ computer experts.

Models for successful teacher development should be developed. Initial or pre-service training focusing on initial preparation on pedagogy, subject mastery, management skills and use of various teaching tools should be organized. The in-service building upon pre-service training and directly relevant to teacher needs can follow this. Lastly, on going formal or informal pedagogical and technical support, enabled ICTs for teacher aiming at daily challenges and needs should also be

organized. Various authors indicated that teachers had to learn a lot to become competent in the uses of ICT for teaching and learning activities and various ways can be applied such as websites, discussion groups, e-mail communication, radio, television broadcasting, guided visits and classroom experiments. Communities of practice can play a crucial role in supporting teacher professional development.

South Africa is not different from other developing countries in terms of the lack of qualified teachers who can handle ICT integration. The government has played a crucial role in providing ICT infrastructure to schools. A number of ICT initiatives have been in place to increase the prominence of ICT, e.g. SchoolNet SA to provide online, mentor-based in service training for teachers on introducing ICTs into the curriculum and management. One of the aims of the School Net SA for ICT professional development includes:

- Use ICT effectively to improve the day-to-day efficiency of teachers.
- use ICT to support existing teaching practices (e.g. by locating and adapting online teaching resources)
- change teaching practices over a period of time (by introducing new pedagogies enabled by ICT)

Another recent programme is run by Intel "Teach to the Future" which is a Teacher Development Programme aimed at providing teacher training in ICT integration into teaching and learning. Provinces are at different levels of ICT integration in education (White paper, on e-Education, 2003) Western Cape, Gauteng and Northern Cape are slightly ahead of other provinces.

Teacher training and professional development programmes are developed, but the policy makers need to provide appropriate training and programmes that are going to meet the curriculum needs. Further more the government has a major role to play in bridging the gap between these provinces or rather keeping other provinces on par.

3.9. Factors affecting the effective use of ICT.

Research has been done by various authors on the uptake of ICT in education, including studies on the effects of teacher training (Cox, Rhodes & Hall 1988), levels of resources (Cox, 1993) teachers pedagogies and practices (Watson, 1993) and teachers attitudes (Woodrow, 1990). It is clear from previous literature reviews that despite the teacher training programmes, there has been slow uptake of ICT in schools by the majority of teachers as some teachers have shown significant resistance towards effective use of ICT. Bliss, Cox and Chandra (1986) concluded from a study that although the general attitude of staff towards ICT was positive more than half had misgivings. Willis (1993) indicates a number of barriers common to all change but which may have a particular resonance for why *efforts that involve technology may be particular difficult to pull off*. Cox (1999) gave factors that influence teacher's use of ICT.

In the research conducted by Cox (1999) factors that influence teacher's use or non use of information and communication technology was indicated including:

- **Understanding the need for change**

Teachers are seen as the largest group of trained in the world (UNESCO, 1996) and are considered the largest force against change (Visser, 1997). According to Fullan (1993), teacher educators don't know enough about the subject matter, and they don't know how to understand and influence the conditions around them. Shifting pedagogies, redesigning the curriculum and assessment will help in optimizing the use of ICT. Introducing ICT to aid education is part of a larger change or reform process which is vital to the successful use of ICTs.

- **Questioning professional practices**

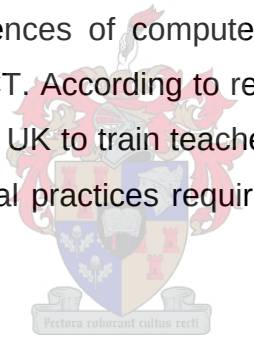
Underwood (1997) argues that teachers are not given to questioning their professional practice. They tend to be satisfied with what they have gained and unlikely to question prevailing educational processes (Desforges, 1995). For instance after attending a workshop, they do not expect to need much further training and

therefore do not take the initiative to improve their practice and learn new skills. A considerable effort to create the possibilities of restructuring knowledge about teaching and learning in the face of experience is needed so that teachers can be able to change their professional practice.

The success of effective integration of ICT will depend on the ability of teachers to question their traditional practices. Teachers are believed to operate in isolation, and fail to reflect on their experiences. This contributes largely on the failure to plough back what have been learnt during a training workshop.

- **Pedagogical practice versus technical skills**

Poor experiences when using ICTs or software was reported that reflects their lack of professional confidence in the role and use of resources. Personal preparedness, unanticipated negative consequences of computer use was reported as potential barriers for the effective use of ICT. According to research by Cox et al (1988, 1994) the majority of ICT courses in the UK to train teachers have focused on the technical aspect rather than on pedagogical practices required and how to modify the ICT to support the curriculum.



- **Support from the whole school**

Gustafson, T.J (1985) indicated that teachers either make or break the innovation meaning that an enthusiastic teacher can carry a mediocre project to completion whereas a negative teacher will sabotage the best of all. Fullan (1991), Gustafson (1985) and others suggested that in order to integrate ICT effectively, one must get the interest and support of the people must be actively involved in adopting innovation. This implies that organizations (schools) can form committees in order to broaden the base of support, encourage feedback on a regular basis to keep people informed and encourage them to share ideas and experiences. Further classroom assistance must be provided by local staff in form of meetings, class visits etc.

- **Losing control of the learning**

Hall and Rhodes (1986) argued that some teachers regard ICTs as a distraction in the classroom and do not believe it has yet had positive effects. Teachers find it difficult to introduce certain topics using ICT such as problem solving skills that were not in the regular curriculum and that could not be assessed (Hawkins and Sheingold, 1986. Based on previous research, Gross (1971) reported that lack of clarity was a major cause of failure. Olson (1988) also indicated that teachers felt bereft of influence, unable to monitor their activities and not sure about their proper role. Heywood and Norman (1987) suggested two major causes of low or zero use of computers by teachers namely: competence and confidence.

- **Inadequate resources.**

Research indicated that the lack of resources is a barrier of effective integration of ICT. This statement can be questioned based on the findings of various researches on reasons why schools have failed to use computers that were provided by government. Time versus the available resources and classroom management contribute largely towards the effective use of ICT.

There is evidence that the project teachers that were given portable computers to develop their own personal ICT skills have shown teachers started to use them in their teaching as well. Barman (1978) highlighted that 100 successful projects spent a lot of time and effort on teacher retraining and support, as it is found it useful to provide teachers with practical experience in applying the ICTs. Olson (1995) supported this statement indicating that teachers are not given enough time to reflect on their own practices and change. Pelgrum and Plomp (1991) also highlighted difficulty of access and time as key barriers to effective integration of ICTs.

A number of factors, which could/will contribute to teacher's perceived usefulness of ICT, were identified. These factors will be taken into account in more detail when discussing the findings of the research**.**

CHAPTER 4

RESULTS, FINDINGS AND DISCUSSIONS

Introduction

In this chapter, the results of qualitative research data are presented. Findings discussed in this section of the report were drawn from a variety of sources such as teachers, school principals, learners, members of the community, observations and informal discussions with students, student diaries as well as e-mails. Secondly, this qualitative research involves data generated by the author as she was a participant in the DEEP project. Data analysis will also be based on the feedback from unstructured interviews, cluster meetings, class visits as well as the available literature on DEEP.

The aim of this analysis is to understand whether the integration of ICT into school practice has worked. Data analysis will focus on the research objectives of the study. In presenting the findings of the research, the three main research questions will be addressed in turn. The DEEP research questions were:

- What is the impact of ICT use on the pedagogical knowledge and practice of teachers and the communities in which they live?
- What is the impact of ICT – enhanced teaching on student achievement and motivation?
- How can teacher education and training be developed to ensure teacher capacity to exploit the potential of ICT?

More findings based on the framework displayed in chapter 3 will also be set out, together with additional information raised by the research study. In the first two sections, the author sets the scene by considering whether learners' and teachers' confidence and motivation or lack there-of was affected by the integration of ICT. This sets a framework for examining the impact of ICT on teachers' pedagogical beliefs, and is followed by a discussion for further ways in which knowledge management tools were used collaboratively to enhance teaching and learning. Lastly, there is a discussion for how the ICT integration can change teacher identities and how teachers had overcome the limitations of handheld computers.

4.1. Learner confidence and motivation

According to the interviews with the school principals, it is evident that there is a high rate of computer use by learners. The high rate might be partially due to the learners' motivation and positive attitude towards computers and also because these technologies were like new toys and learners were curious about them.

Fig 2: Shows how learners have used the digital technologies for learning inside and outside the classroom.

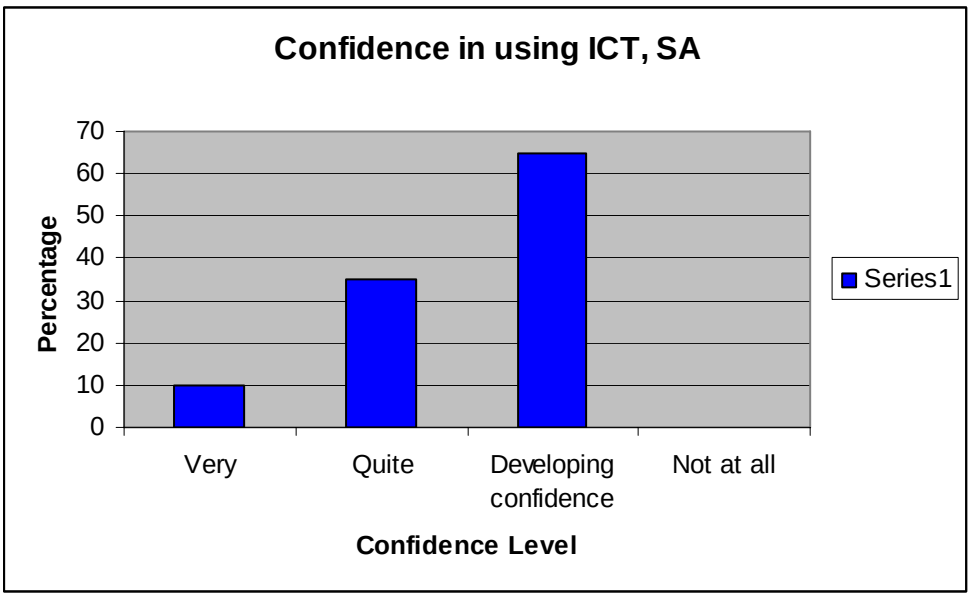


Fig 3: A graph showing the attitude of learners towards the use of computers.

DEEP teachers reported that learners were keen to manipulate the new forms of ICT that they were not familiar with and were also ever ready to explore the new machines. Classroom observations showed that ICT use by learners encouraged peer tutoring where learners felt confident to teach and learn from other learners and take responsibility of their own learning. One of the teachers' reported that learners were demonstrating independency, ownership and creativity towards their school work. ICT offered learners' opportunities to share their expertise with peers, particularly when teacher confidence with ICT was limited and pupils were more self-sufficient.

Most teachers interviewed were of the opinion that learners' attitude towards learning changed for the better with the introduction of ICT. They claimed that learners had developed a positive attitude towards their work, spent longer hours completing their activities and showed more commitment to their learning. Cox, et al. (2004) supported this claim stating that research evidence shows that ICT can stimulate, motivate and spark student's appetite for learning and helps to create a culture of success. The teachers reported that there was much more interaction in the classroom than before. Pairs, groups of 4- 6 learners were reported to be interacting positively, discussing and sharing ideas on how to handle different activities. Based on the authors' observations, learners demonstrated a high level of participation and engagement throughout the year. The first group that participated in the project was regarded as pioneers and they have shown outstanding work which was show-cased during the affirmation ceremony.

Generally speaking, learners were confident because they had more access to computers than their teachers and they would proudly show their expertise in front of the class. Children with limited personal, social and academic skills were also seen offering each other encouragement and positive feedback. The teachers then later reported that ICT is no longer for those who can perform better, but all learners are given the same opportunities.

Classroom observation results indicated that friends worked better together than teacher-selected partners. Learners reported that they were more relaxed and stress

free when working with their friends. According to the students and teacher reports ICT was mainly used for *Science*, *Languages*, and *Mathematics* and sometimes used for other learning areas like *Life Orientation*. The interaction and helpful relationship observed in the electronic pictures was confirmed by interviews with both teachers and learners. Based on these findings it was clear that the integration of ICT supported teaching and learning and also motivated the learners in many ways. The motivation of learners seemed to involve an emotional *feel good* factor:

To quote one learner: "*It is so good to use the hand held computers, PDAs, digital cameras etc and actually use PowerPoint presentations*"

(Ntsika Mdledle Grade 9)

Another learner responded by saying: "*We are so privileged this year to have access to laptops; playing with it all the time, and that makes me feels good and happy*". (Aneza Zoya Grade7)

Based on classroom observations learners behaved very well and they have developed team spirit and continued to be motivated. Learners displayed a high level of cooperation and support for each other and even towards their teachers. One teacher commented that …… *is our new instructor, he actually solves most of our technical problems whenever we are stuck*.

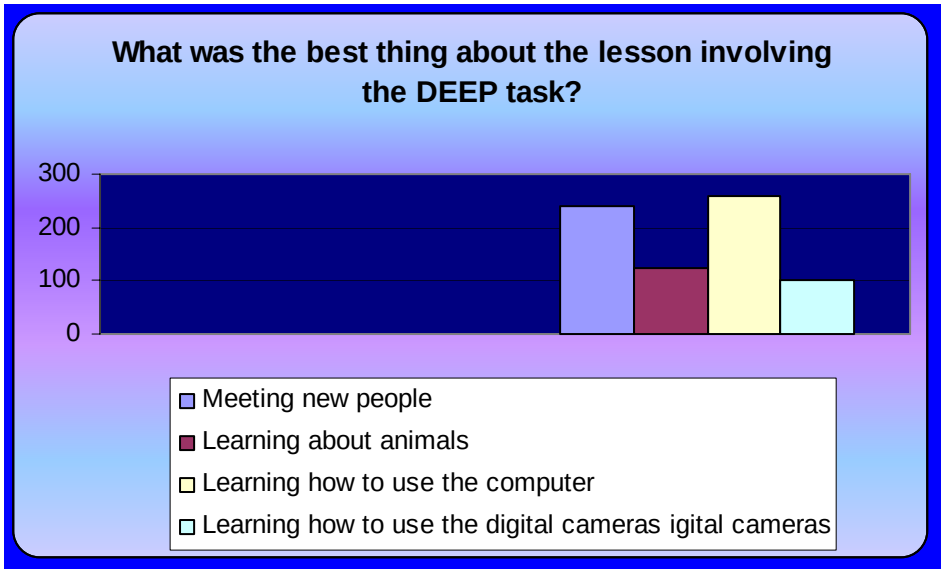


Fig 4: Learners indicating the best thing about the DEEP activities.

(Baso from Eyethu J. S. S)

4.2. Teacher confidence and motivation.

Previous studies into teachers' attitude towards ICT (Cox and Abbott, 2004) have shown that the use of ICT will depend upon teachers' attitude and confidence. A study by Gilmore (1995) supports Cox and Abbott's argument that teachers using computers in their teaching had increases in confidence and used ICT to provide cognitive and social benefit for teachers and students. Literature review suggests that educators need to be confident in order to integrate ICT into the curriculum effectively.

Based on classroom activities, evidence of teachers' motivation and confidence is shown by the range of teacher and learner products and ICT activities that are available on the DEEP website. Contrary to Preston et al (2000)'s argument that, some ICT coordinators and teachers rarely used any ICT applications other than word processing more than once a month, the DEEP study showed that teachers used a variety of programmes to support teaching and learning. Displays of acrostic poems, PowerPoint presentations, photographs taken, brochures designed, and other materials proves that learners' attitude towards the ICT use was outstanding.

Another aspect relating to confidence is the teachers' approach and role when using ICT in their lessons which in some cases suggest passing the leadership role over to the ICT environment.

Heywood and Norman (1987) suggested two major causes of low or zero use of computers by teachers were *competence* and *confidence*. Their argument was supported by the findings of this research study. It was clear that the teacher anxieties are not often based primarily on the technology, but rather on their own ability to use it for good educational purpose in the classroom. A portion of the teachers was reluctant and shy to use the computer in class since they were also learning. Teachers reported that in the beginning of the project not all of them were ready to use the computers. Some experienced teachers were very confident users of ICT and more often used it for themselves. More contact with the ICT helped them to gain more confidence and overcome the fear of using the computers. Others were anxious about the lack of expertise, and feeling quite frightened of getting it wrong.

With the assistance of the project partner, more teachers gained confidence as they were working together to assist each other when ever necessary. Outstanding support from the principals, staff members and community members also contributed towards building confidence. During the lifetime of the project teachers grew significantly in their confidence to use ICT.

One teacher in the Eastern Cape said one of the main barriers to further integration of ICT throughout the curriculum is teachers' fear of using computers: *some are frightened that computers will explode if they press the wrong key.* Another teacher (Eastern Cape teacher, 2002) asked; *why is this computer not working now?* Sasa answered; *it's because you are not clicking properly; your hands are too soft.*

Interviews with teachers indicated clearly that teachers thought that integration of ICT has been successful in supporting teaching and learning. A teacher echoed that: *we cannot survive without computers, we are used to teaching with computers.*

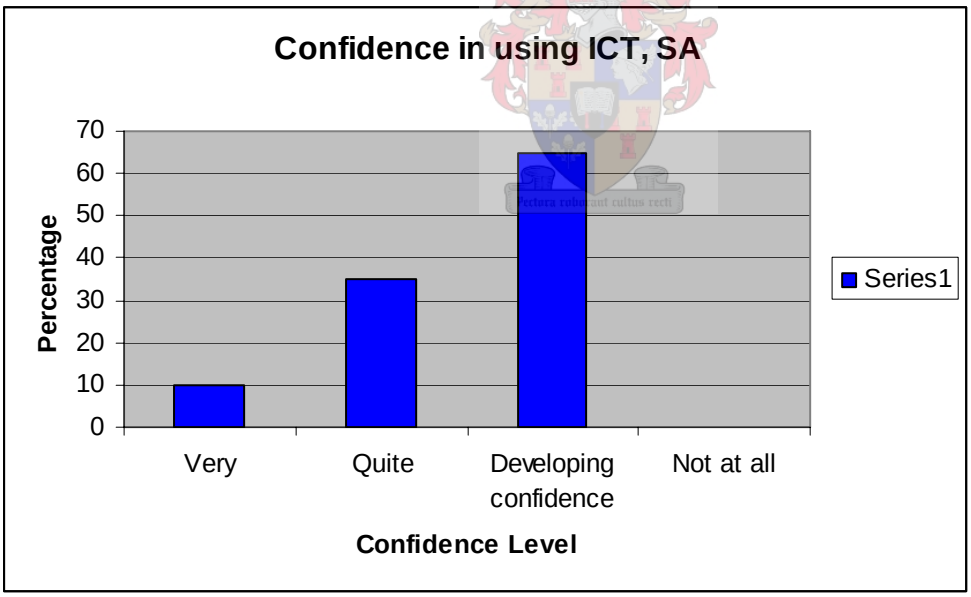


Figure: 5 Confidence in using ICT

4.3 Impact of ICT on teaching and learning

The findings of this section report on how the DEEP participants have used the handheld technologies to enhance the quality of teaching and learning. Details of the ICT software and hardware used in the classroom will be given to further illustrate insight into the impact of ICT for teaching and learning.

- 100% of teacher participants cited that a laptop provided participants with access to unlimited information. Portable laptops were seen as a way of motivating and empowering participants to use ICT in their own privacy and own pace. Laptops boosted the image of the teachers since laptops were mainly associated with business people. Laptops were further used to demonstrate both the teachers' and learners' work at all stages. Learners and teachers gained literacy and presentation skills. Participants became more confident and competent in using ICT. More knowledge on how to use the computers effectively together with other software and hardware resources was gained

- Positive response on the impact of ICT on administration to support teaching and learning was reported by most of the participants. Laptops and internet were used to download the latest developments in the education system e.g. previous matric papers, curriculum developments as well as educational activities. Recently Internet was used to download material for the implementation of National Curriculum Statement documents for the Grade 10 learners.

- Access to laptop has encouraged teachers to plan their lessons in advance - leading to improvements both in terms of time management and professional quality of the work presented. Various programmes such as Power Point presentations, Excel, Publisher etc. were used to present information differently and professionally, e.g. the PowerPoint presentations. Laptops were also used to make class lists and record marks using the Excel program. Teachers noted that a laptop enabled them to use laptop applications at school and at home and it has helped them to manage their administrative duties as well.

Furthermore, ICT was used as a information resource for the learners and teachers. Participants who were and are currently involved in further studies used the laptops and internet facilities to research more information from various websites and also used it for WEBCT discussions. Laptops were in addition used for community purposes, including, meeting programmes, notices and minutes of meetings.

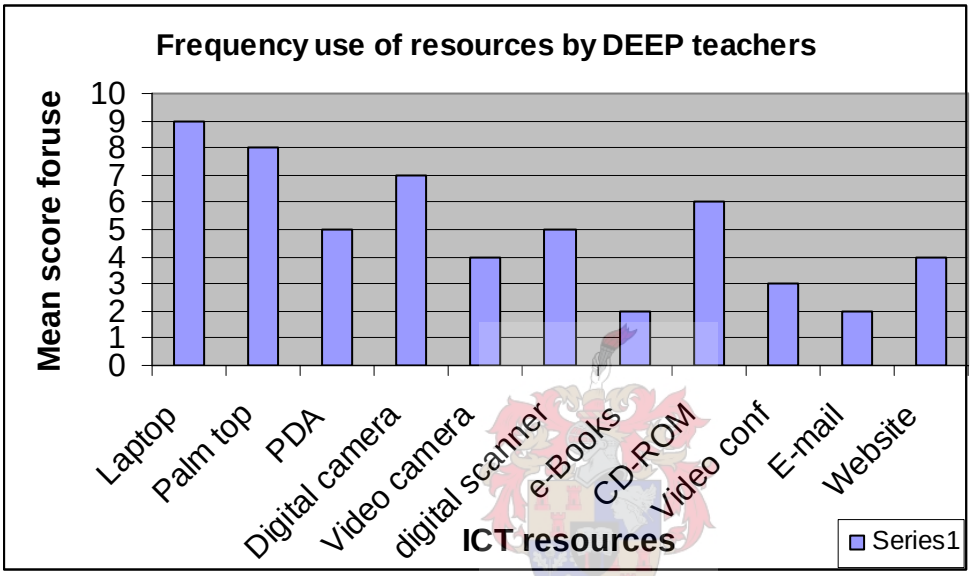


Fig 6: Use of ICT resources by DEEP teachers.

The level of use by teachers is relatively very high since teachers had to explore how to use of these ICTs. Observations indicated that some programmes were not used as frequently as others e.g. e-books. Teachers reported that the reason for the low level for the use for e-books is mainly because most of them lost the thread of the programme if they had not used it for some time. Teachers also indicated that they were still familiarizing themselves with the programmes that they were used to or which looked simple to use.

4.4. Developing pedagogical knowledge and practice

The main key findings of this section are based on the research question no 1:

What is the impact of ICT use on the pedagogical knowledge and practice of teachers and the communities in which they live and work?

Observations and cluster meetings show that the use of ICT has led to several changes in terms of pedagogical knowledge and teaching practices. ICT integration has transformed the traditional teaching methods and further extended the range of participating teachers' existing pedagogical practices. Evidence also shows that all project teachers started integrating ICTs into their existing lesson plans immediately after the project launch. Questionnaires that were distributed during mid and end of the project indicated that 88% of teachers considered ICT to be very important for teaching and learning and the remaining 12%, to some extent important. According to Schulman, knowledge can only be transformed once the teachers actively grasp, probe and comprehend ideas and then reshape it into something more appropriate for learners.

Sandholtz, (2001) highlighted that teachers' capacity to use computers in classrooms effectively has not kept pace with the increasing levels of access to constantly changing equipment. The most influential argument will be based on the Deep teachers who used the state of the art technology effectively for teaching and learning. The representations given below will characterize the teachers who have integrated the different components of their professional knowledge of concepts within subject domain to the understanding of classroom strategies that reflect both the needs of the learners and the contexts of educational initiatives.

Evidence showed that teachers with unlimited teachers' knowledge of ICT increase the affordances provided to pupils and complex relationships between pedagogical reasoning and actual use of ICT is developed. Observations showed that ICT use has changed the nature and representations of knowledge and the way the subject is presented to engage learners. Teachers were encouraged to prepare lesson plans well in advance so that learners' understanding can be challenged, and also to promote reflective thinking.

Findings show that teachers were able to determine and apply different classroom practices in terms of grouping and pairing learners. Doing projects, assignments with

the help of the computer is everyday life in other parts of world, but with Butterworth High school learners, it was a dream come true. Learners realized that teachers wanted them to access more information and be creative by employing existing computer applications.

4.5. Developing subject knowledge.

In this section, the author sets the scene by considering whether and how core Science teachers have begun to integrate the use of ICT into their classroom practice. This provides a framework for examining teachers' pedagogic beliefs, norms and practices. The main findings showed that ICT use can enhance teachers' professional knowledge and capability by extending subject knowledge. The integration of ICT tools for teaching and learning Science will be discussed. An important contextual factor which shaped the use of ICT by teachers and learners was the *community of practice* (Lave and Wenger, 1991) in which the Science activities were developed and carried out. According to the data collected from a questionnaire, DEEP teachers claimed that ICT integration had great impact on subject learning.

"The DEEP had a great impact on my abilities in teaching my subject and made me enjoy teaching it. I have started to use the computers in a way that is related to my specialty" (Questionnaire 2003).

Selinger (2001) indicated that for subject lessons to be successful, teachers need to have robust subject knowledge. The DEEP programme was structured in such a way that subject matter development was integrated with new pedagogical knowledge through classroom-based activities. Science activities were developed based on the curriculum requirements, e.g. Theme: *Life and Living*. Teachers were enthusiastic about the strategy and further requested that cross curricular themes be developed within the project, such as *health, citizenship* etc. The reason for making these suggestions was that teachers wanted to extend the activities according to other learning areas/subjects. Teachers and learners extended their subject knowledge and applied the ICT integration in other themes that are also relevant to the Science curriculum e.g. *Force and change* and *Earth and beyond*.

In the interviews, teachers declared that technical and subject based training that was offered at the beginning of the programme empowered them to extend their subject knowledge. There is evidence that teachers' skills were increased and they became more adept at maximizing the power of ICT to meet the learning outcomes. This is evident when looking at the samples of activities that were performed by both learners and educators. The flexibility and portability of ICT devices, increased familiarity with relevant software, extended the subject knowledge as they had more time to explore what these ICT had to offer and how to use it effectively. DEEP schools have taken a lead within the Eastern Cape education context in changing teaching and learning strategies that will help in empowering the learners in living in today's technological world.

According to Cox et al (2004), teacher's subject knowledge influences how ICTs are used in lessons. They showed that teachers content mastery and understanding of student comprehension, has more direct effect on student attainment and achievement. Evidence showed that the effect on attainment is greatest when pupils are challenged to think and to question their own understanding, rather than exposure to new additional information. Classroom observations showed that the use of ICT has raised the quality of teaching and learning in schools and communities which are starved of resources and information (Leach, J. 2004) and ICT can aid teacher self learning in subject matter. According to the DEEP report 90% of the educators used the project resources for subject knowledge. Given below are examples of various activities that were performed by learners and educators to improve their subject knowledge. Choosing the best software which is relevant to the content would lead to high learning gains. Based on the project data e.g. samples of work collected, ICT served as concurrently as a means of developing teachers' subject knowledge and as a pedagogical tool for enhancing students' scientific and information literacy.

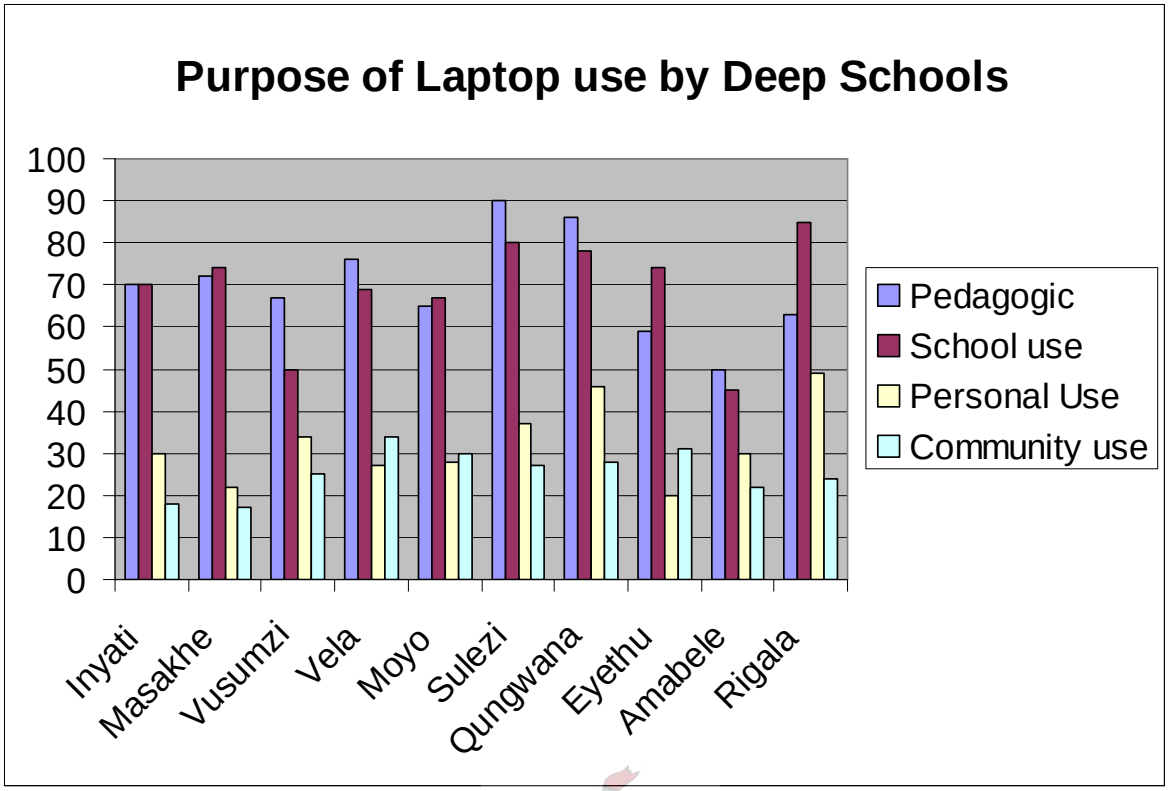


Fig: 7 A graph showing the purpose of Laptops by DEEP teachers.

Fig 8: PDA and camera used during the field trip on solar expedition. Photography skills are also gained

Fig 9: Learners used the laptop and photocopier to make acrostic poems and practiced ICT skills like Power point presentations etc.

ICT was used as a tool to communicate.

Grade 7 learners were observed when presenting the movies that they had developed about different animals. They enjoyed the lesson and they were fully prepared. Learners were reported to be very excited about having a movie of their own. Technical problems were experienced during this activity as there was no sound produced. Learners reported that the set-back was ignored for that moment but later on, learners managed to solve the problem through trial and error.

Within the Science domain, learners demonstrated the understanding of constructing Science and technological knowledge, developed problem solving skills, hypothesizing scientific relationships, scientific reasoning and explanations. The Revised National Curriculum Statements (RNCS) requires learners to be able to classify, recalls meaningful information, evaluate and communicate findings.

4. 6. Teacher - training and professional development.

Teacher training and professional development in ICT for teachers is stressed worldwide, and equal emphasis needs to be placed on administrative training for knowledge management, teamwork, community relations and creating a culture of innovation and of mistakes. Ongoing teacher training and support is critical to the successful utilization and integration of ICTs in education. Teacher training and professional development is regarded as a key driver for the successful usage of ICT in education. Based on the statement made in (chapter 3) that teacher training and

development should be seen as a process, not event, DEEP participants attended a number of training workshops.

Fig 10: Deep educators during a training workshop (March 2005)

One of the key findings of the DEEP research was that most of the teachers were novices and had never used computers for teaching and learning before. Prior to the launch of the project, teacher participants were trained on basic computer skills and taught well by IT specialist. The workshop was conducted at the University of Fort Hare's science laboratory. The training was three days long and followed by a four day launch workshop. Participating teachers had to stay in the hostel as they were widely distributed in the Eastern Cape. The Launch workshop was curriculum focused and different activities were done. Project partners, worked in groups based on geographical location on collaborative, as well as linked individual tasks. Activities that were prepared by the researchers were experimented and were to be repeated when back at schools.

During this period issues of great concern such as security, introducing the DEEP (ICT activities) at schools, involvement of the community in the project were discussed. Affirmation event which is part of the government policy in the Eastern Cape was organized on the last day. The workshop was concluded by issuing of certificates to the participants and presentation of the hand-held computer in the presence of their school principals.

Research literature suggested that in-service training including structured face to face distance learning opportunities building upon pre-service and directly relevant to teacher needs is an essential aspect of ICT integration. A number of mid-project workshops were held in May, August and September. Cluster meetings were held where progress and challenges encountered by project participants were discussed. An IT specialist offered continuous technical support.

There is evidence that teachers worked collaboratively with ease in various settings including, outdoors enabling the curriculum specialist to model a range of individual, pair and a group approaches to curriculum activities. The participants appreciated the 24 hour access to computers which would in return enable them to practice computer skills at their own pace and also overcome their fears. It was evident from the training workshop that ownership of security issues, constant focus on the importance of community involvement, development of mother tongue resources, group activities based on clusters was most important.

According to Becker and Riel (2007:20) teachers who are deeply involved in professional activities are more likely to have teaching philosophies compatible with constructivist learning theory, teach in ways consistent with a constructivist philosophy and; use computers more in exemplary ways.

4.7. Knowledge management tools for collaboration.

Butterworth High School was able to draw on emerging practice and joined an international project encompassing a video conferencing approach. DEEP participating schools in South Africa (mainly Butterworth High School), Walton High School and St Savior and St Olave High School in London were to demonstrate collaborative performances such as sharing music, artifacts, share poems and share their life experiences and discuss issues on global citizenship. The three participating schools were linked on a monthly basis, and teachers had their own session to discuss, plan the future activities as well as give feedback on previous activities. University of Fort Hare branch in East London (South Africa) was used as a study

centre as the DEEP schools do not have the necessary equipment for connecting. One DEEP teacher won a web camera during the training workshop but lacked the expertise of using it effectively for the benefit of the learners. Actually, she did not know when and with whom would she ever be able to use it. After, the first video conferencing, educators and learners realized that the small tool has the potential to remove all the geographical boundaries and make connections with overseas institutions.

Cifuentes and Murphy (2000) indicated that video conferencing has raised the academic aspirations of teachers, as their learners discuss with more assured students, who become positive role models. One parent congratulated the participating teachers stating that *our children now will no longer be entitled to stay in South Africa if they are exposed to these kinds of ICTs, and London now is in East London.*

Literature showed that students who are normally hampered in school activities by poor literacy skills, are the most active and competent participants in video conferencing. Some of the participating learners displayed the same kind of behavior. Vuyo who is shy in class asked one of the teachers to excuse her from participating in the next video conference, which was aimed at sharing poetry. The teacher responded by asking her a question:

Have you imagined yourself speaking in front of the TV before you joined DEEP? She responded by saying *No, you are right I'm back, I can't quit because really I'm not shy anymore and after the Life Orientation workshop that I attended I gave a detailed report in front of the whole school and everybody was shocked by the way I spoke*. *DEEP has changed my personality and I'll have to change my attitude towards poetry.*

For Butterworth High School as a whole, the video conference enabled the school to connect with one of the schools in London (St Savior and St Olaves) to develop language skills, exchange programmes on leadership that will be in March this year for the school principal and followed by learners. The next section will reflect on the impact of ICT integration on the personal development of teachers.

4.8. ICT can change the teacher identities

Generally speaking, teachers were not motivated, depressed and helpless in terms of policies imposed by the government. In the past teachers were well respected by their communities as opposed to the current situation. Currently, the majority of teachers have a very low self esteem and therefore, the community has lost respect and trust in them. Many factors contributed to that such as physical harm caused by teachers on children, violation of children's rights, sexual and verbal abuse as well as socio -economic status of teachers. Another point that also contributed towards the loss of respect for teachers is the negative comments that are often made through the media especially by those in authority.

Based on the DEEP report, participating teachers were not different from the rest of the group. It is reported that during the first research visits, teachers indicated they have a low self esteem and lack professionalism. The author of this paper supports these claims based on her personal experience. DEEP teachers gave testimony to the way in which their self-esteem, self-image dignity and professionalism have improved. Staff members feel trusted, empowered and encouraged to take on new ideas. The school principals within the projects schools are encouraging the teachers to be involved in projects of all types with appropriate financial incentives.

According to Leach (2000) learning is described as a process of developing identity of becoming. She argued that learning transforms who we are, what we can do and what we believe we are capable of doing in the future. Informal interviews and discussions with other DEEP participants clearly indicated that more has been gained and they have grown professionally. As educators, they have taken new opportunities and they were faced with challenges that have in return empowered them to grow abundantly in various educational practices. The positive attitude that has developed within the teachers enhanced learners that have already committed themselves to learning and even those who displayed some weaknesses.

If the education system must change, the teacher's identities must also change and the suggestion I would like to offer is that teachers must be vocal, accept change, and take initiatives that will bring back their dignity.

Some of the ways in which teachers have changed their identities are given below:

- More teachers than ever are encompassing the concept of personal mastery, for example being involved with higher degree courses e.g. Honors and Masters Programme with various universities in South Africa
- Participated in other ICT related projects such as Intel teach to The Future and School Net SA
- Participated in the World Commonwealth conferences and links were established thereafter.
- Some DEEP participating teachers identified themselves as experts who can help their colleagues when experiencing problems
- Outstanding support and professional recognition by other teachers and the community and District Officials.
- Some DEEP teachers have written International Computers Drivers License (ICDL) exams in order to gain more recognition by issuing certification.

The community has changed the way they used to think of teachers because principals speak openly during meetings about the way the DEEP has changed many aspects of the education system. Parents are pushing their children to come and study at the DEEP schools. One parent showed his appreciation by donating Microsoft Encyclopedia to be used by the whole school. Parents of learners who often stay late at school support the work done and never complained about keeping learners after hours for further project work. Information and communication technologies were grounded into personal knowledge and integral to the user's identity. DEEP teachers indicate that they feel proud and they have gained a sense of belonging perfectly well in a wider community.

4.9. Benefits and limitations of using hand-held computers

4.9.1 Benefits

Prior to the existence of the DEEP, some teachers had little or no knowledge of computers; some had never touched a computer before. One starts to wonder how it would be possible to use these new technologies to the advantage of the school with such limited information. Literature review showed that educators need to be

confident in order to implement ICT into curriculum effectively. Commenting on the benefits of the hand- held computer use, teachers and learners indicated that

- Teachers know that their students will have ready access to the technology and can plan classes accordingly
- Students can take advantage of the technology at the time it is needed and at the place it is needed
- Teachers have access to the technology continually. Work started at school can be continued at home
- Through regular use of the technology, students and teachers develop advanced skills in a meaningful context and through continual reinforcement
- Students ownership of notebook computers relieves the school of the need to regularly upgrade and extend the hardware facilities
- Mobile computers facilitate delivery of cross-curriculum computing

4.9.2. Limitations of using the hand held technologies.

Much has been said about the potential benefits of ICT for human development, but much less has about its possible negative consequences. It is important to identify the potential threats posed by ICT use so that strategies can be developed to neutralize them. The teachers were asked questions on the limitations of these technologies.

Interview comments and group discussion indicated that teachers experienced both pressure to use ICT and a desire to exploit the technology and change pedagogy accordingly, but at the same time, a set of constraints on the use emerged. Some of the limiting factors were discussed earlier and ways of dealing with each situation will be indicated. It was discovered that despite all the challenges faced by teachers in integrating ICT, teachers remained motivated and empowered to solve technical and security issues strategically and successfully.

It is also evident that there were considerable challenges to overcome in integrating and using ICT for teaching and learning. These challenges will be discussed as follows.

a. ICT classroom and management issues.

Eraut, M (1991) stated that much work with computers is carried out under considerable practical difficulty because of the circumstances beyond the teacher's control. Michael stated three practical problems related to classroom management, which will be discussed in relation to what happened in the DEEP context namely:

• Problem of access to computers

Poor access to ICT facilities seems to be an important factor behind many of the critical judgments. In all of the project schools, making use of the computers to support teaching and learning depended heavily on gaining access to specially equipped ICT rooms. Access to facilities was opportunistic and problematic in most project schools and the percentage of curriculum time using ICT was minimal in all subjects. Time allocated was not enough for full participation and project schools could not afford to buy more computers.

Becker, (1984) highlighted that computers are expensive tools, that may amount to only 20 minutes access per pupil per week. In most project schools, there were more than 35 learners in each class and one laptop was provided for teaching and learning. Teachers were expected to use and make sure that all learners have access to this one laptop. In the beginning it was quite difficult to use, but later teachers developed some skills and strategies of using the laptop effectively within the given space and time. Initially, there was no time allocated for teaching computers or teaching with computers. Later on, time table arrangements were made and that allowed learners extra time to work with computers. Groups were organized and activities had to be planned in advance. Parallel planning though not part of the same topic was the necessary option to accommodate the integration of portable computers.

• Problem of location

Computers had to be carried from class to class and classrooms had to be reorganized constantly. Various grouping methods were applied to allow for the

development of social skills. The problem of location further required teachers to organize the work to maximize computer usage rather than achievement of learning goals (Johnson 1985)

Discipline is rarely an overt problem with children working at computers because of their high motivation level. Teachers used various strategies to instill discipline in their classrooms. Some teachers gave incentives to disciplined groups; some groups would be allowed to use computers after school for their good behavior. At some schools learners took various roles like material or equipment handler, group leaders, harmonizer etc. By applying these roles learners were encouraged to discipline themselves. Classroom rules were drawn and amended in order to discipline learners.

b. Technical issues

Leach, (2004) stressed that technical support and teacher ICT skills are very crucial aspects of integrating ICT and that skills might compensate for each other. Research suggests that technically skilled personnel must be placed in all schools that have adopted portable or desktop computers for student use in order to provide technical support. One starts to wonder if schools especially in the Eastern Cape would be able to afford such services.

Teachers report that an IT specialist and technician were hired for technical support in all project schools in the Eastern Cape. The IT specialist took turns to visit all the project schools and provided technical support. Since the project was new as well as the kind of technologies used, every minor problem was reported as participants were not sure whether the equipment was broken or not. Mobile phones which were not provided by the project seemed to be the most effective and economical tool to use. Find the samples of SMS from the project teachers to various players within the project:

[DEEP] our computer cannot log us in. It says our account has been locked out and we should consult our administrator.

[Thembie]

Dear [DEEP]

There is a slight problem when trying to log on. The username is DEEP and the password is ……. You logon once and then the second time when verifying the password, the message is shown. It goes on like this, Unable to log you on because the account has been locked out, please contact your administrator. It is so difficult for us, as we are unable to use the laptop. Please help us sort out this problem. Thank you [Tommy]. E-mail was another alternative used by participants to report challenges and also share information with researchers in Open University and also locals. Creativity was demonstrated to handle some of the technical problems experienced by the teachers. Teachers reported that faulty PCs were to be taken to local technicians and later inform the project team at the University of Fort Hare and Open University. Teachers also reported that they were willing to spend their own money in order to make sure that their equipment was working.

According to the discussions with school principals and teachers of DEEP, damaged computers were taken to computer shops around East London e.g. Compusys and Sainet for Internet related problems. Teachers also reported that information on how to solve some minor issues was shared among the participants through short messaging system (SMS). This is regarded the best option as it is cheap to use and fast.

Sometimes, participants would send SMS to Open University research team to ask for assistance. Symes (1997) felt that personal and prompt assistance must be readily available if the technology is to support and not hinder the educational endeavors of the school. The majority of the participants who once experienced technical problems strongly supported this claim. One teacher stated that, “I can’t wait to have the laptop back”, and the other one commented that it was very difficult to work without the computer. Cuban (2000; 1996) strongly argued that the lack of technical skill is not holding up effective integration of ICT in the school curriculum, but rather holding back the development of effective classroom practices using ICT. Sometimes, educators loose their data due to the failure to synchronize their handhelds with their laptop computers. When data loss occurred, certain applications such as E-books, and multi-media applications would also disappear and needed to be installed.

DEEP participants who have a reasonable amount of technical skill and who use computers to address their own professional needs use computers in broader and more sophisticated ways with students than themselves. Some of them claimed to have become technicians overnight.

c. Security issues

Security has raised a number of concerns especially because of the nature of the project tools. Laptops, video cameras, PDAs are the latest technologies that are in demand these days. Eastern Cape has a high crime rate especially the former Transkei where most of the project schools are. Security related issues were discussed on a number of workshops and revisited on a regular basis. Recommendations were made in connection with security measures to ensure that the supplied devices were secured. Teachers came up with plans of how they were going to secure their equipment and schools shared various ways based on the structure of their schools.

Strategies that were applied in securing the equipments will be discussed below:
Teachers reported that

- One school kept the equipment in the strong room and later, the project teachers together with the administration of their school felt it necessary to let them take the equipment home on a rotational basis for extra use and preparation. Fortunately for them, it was just a walking distance and there was no need to panic about robbers. Extra care was taken when traveling long distances e.g. the original bag would be replaced with ordinary bags to disguise the contents of the bag.
- In some schools computers were stored in one of the School Governing Body houses. Learners used the unpopular bags to carry the equipment to and fro. Class leaders or representatives worked on a rotational basis to collect from and return the equipment to the village where it is kept after school. Some project partners relied heavily on the public transport that they were using to drop and pick them up after school.

According to the (DEEP report 2004) the main findings indicated that there were only two hand-helds that were stolen, one from the researcher in London and one in the teacher's apartment. The majority of the equipment provided to the project remained in working condition and 4 laptops were replaced due to non- functionality (unconnected to damage or misuse by project teachers/ learners). Despite all the challenging factors, such as lack of direct technical support, over use by various learners and teachers, harsh working conditions, the survival of the project equipment was no worse than one might reasonably expect in schools anywhere in the developed world.

I strongly believe that the way the equipment has survived in these conditions challenges the policy makers to review their argument about ICT use in rural context. As indicated earlier, both students and teachers demonstrated a very high level of caring for their highly valuable and expensive devices and retained them in good working conditions. The pedagogical development and technical development were in good balance and from the beginning; the pedagogical use of ICT was appreciated and nurtured by most DEEP schools.

Although the use of ICT in the Eastern Cape is relatively low as compared to other provinces in South Africa, DEEP and other projects has empowered the teachers, learners, school managers about the implications of integrating ICTs. All the stake holders have a responsibility to choose the correct resources and strategically plan how ICTs can be integrated effectively into teaching and learning.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS.

Introduction

Today while some teachers and students fear to handle information and communication technologies, others are embracing it enthusiastically. ICT has proved to be an excellent tool for teaching and learning right across the curriculum, not just Science. The most crucial point derived from the literature review is that ICT can be used as a powerful instrument to improve effectiveness of the transmission and absorption of knowledge. ICT allows changes to be made in the curriculum content, classroom organization, teacher-pupil relationships and evaluation techniques. In addition, ICT use in the curriculum expands and reinforces computer literacy skills.

The success of the DEEP project depended heavily on the nature of the programme as well as the *state of the art* technologies supplied. Both learners and educators were motivated by the kind of technologies they manipulated. This research analysis presents a number of implications for the implementation of ICT in schools. Firstly, those responsible for any initiatives must be clear about what they are trying to do with the ICTs and show understanding of the appropriate approach to curriculum development.

Secondly, the government policies and strategies to support the linkage of ICTs to curriculum development reveal a pattern. Changes in the use of ICT require engagement with teachers concerning their views (subject, school and pedagogic) as well as the teachers' personal construct (Leach, 2001). Educators have a crucial role to play during teaching with ICT if high order thinking is to be developed. The current status of educators necessitates training of educators as well as implications of doing so. Broadly speaking, not much has happened in the Eastern Cape in terms of ICT implementation and integration into the school curriculum, teacher training and provision of ICT infrastructure. A lot still has to be done and it is hoped that projects

like the Mandela Foundation, SchoolNet, and Intel “Teach to the Future” would speed up the integration and training process.

5.1 Conclusions

The findings of this research analysis and synthesis lead us to document strong support for ICT as a component of our pedagogical practices.

- In this study an attempt has been made to review literature on the effective integration of ICT and its implications.
- Evidence showed that ICT can improve teaching methods and the content of a large number of subject areas.
- ICT if integrated intelligently with the curriculum and pedagogy produces measurable learning gains and can support effective teaching and learning.
- ICT can support relationships and motivation, leading to long –lasting engagement and learning.
- ICT enables some type of learning activities (e.g. discovery learning), facilitates some others (e.g. collaboration, peer tutoring and cooperative learning) that are harder or impossible to achieve without ICTs.
- The portable ICTs such as digital cameras and palm-tops encouraged both learners and educators to change their work patterns as well as supported discussions. Learners enjoyed the use of ICT across the curriculum and showed great enthusiasm. Involvement of the learners in the DEEP project encouraged some parents to buy computers for their children so that they could continue with their computer skills. Some parents felt it is necessary to send their children to schools that offered computers or keep them in their current schools, if such schools offered computers/computer studies.
- ICTs are enabling people and organizations to reduce some of the communicational restrictions of space of flow and time in ways which were until hither unknown.
- The available technologies hold promise for even more exciting gains - if we can keep up with the intellectual challenge of adapting our pedagogies to the realities of the world in which our students live and operate.

- Lack of proper ICT teacher training and professional development is still a challenge.

I conclude that the overall perception of the benefits of ICT was positive for both educators and learners in the study and further suggest that the new digital technologies are appropriate for the use even in the African context and have the potential to support and revolutionize the quality of training and status of teachers.

5.2 Recommendations

- Planning of ICT diffusion should be taken seriously, if positive attributes towards teachers, learners and the community at large, irrespective of the geographical dimensions and socio-economic status of their societies, are to be achieved.
- Choosing the appropriate information and communication technologies is very crucial for the integration of ICTs in the school curriculum.
- Government must play a major role in the provision of sustainable ICT resources that will be effective to achieve the goals set out.
- In order to meet the critical need for qualified teachers without whom the integration of ICT in school curriculum would be meaningless, government should also provide incentives for teachers to encourage and motivate young graduates to value teaching.
- Policy makers should consider the best resources and partnerships to be formed for provision of ICT infrastructure. Marshall, G and Ruohonen, M (1998) suggested that policy makers must be aware of the impact of ICT on society- at large and on education in general to prepare students for the 21st century. More emphasis should be on developing the people's capacity to use ICT for a wide range of educational applications.
- Planning, and in-service training of teachers about need, usage and logistics should be conducted on a continuous basis, before and after computers are placed in classrooms.
- If learners and educators are going to avail themselves for the full potential and opportunities offered by technology to support learning , they must first be provided with the necessary hardware and software, and skills to know how to

use and find what they want from technology supported environments, they must not feel dependent upon those ‘who know’ how to work with technology or those who design the educational software or even the learning environment itself (Burgoyne, J & Reynolds, M 1997)

- Funding and sponsors should be available and accessible.
- Lastly, more research should be carried out in order to bridge the existing gap in the use of ICTs among countries and within the country.

ICTs are of utmost importance if teachers’ pedagogical knowledge, subject knowledge and pedagogical practices are to be transformed. In order for learners to be active participants in the knowledge era, education should be regarded as the most important system with the potential to transform the socio and economic structure of this country.

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APPENDIX A

Application forms

UNIVERSITY OF FORT HARE
FACULTY OF MANAGEMENT DEVELOPMENT AND COMMERCE
OFFICE OF THE EXECUTIVE DEAN
Bisho Campus - Telephone: 27(0) 40 639 2445 Fax: 27 (0) 40 639 2447

DIGITAL EDUCATION ENHANCEMENT PROJECT (*DEEP*)

26 November 2001

Butterworth High School
BUTTERWORTH
4960

Attention: Ms N Klaas & Ms L Witbooi

APPLICATION TO PARTICIPATE IN THE DIGITAL EDUCATION ENHANCEMENT PROJECT

Congratulations! You are one of the lucky few that have been selected tc participate in the innovative Digital Education Enhancement Project*(DEEP*). We hope that you are still interested in participating in this exciting Project. We would like to apolog se forthe delay in responding to your application; this has been due to reasons beyond our control.

Together with our international partners in Egypt and England, we spent the rest of the year developing your course, organising for your equipment and making preparations to launch and get going. We have also decided to commence with the programme at the beginning of the new year in 2002, instead of September 2001 as was advertised.

The year 2002 will be a busy year for you- right from the start! Here is the proposed plan of activities to get us off the ground:

- 09 January 2002: The two participants from each school arrive at All Saints College BISHO (next to BISHO Hospital) at 17h00.You will be guided to your place of stay for the next week.
- 10 January to 12 January 2002: Initial computer-literacy training workshop designed to introduce participants to the world of computers. Remember that*DEEP* is focused on the use of computers for teaching and learning and no: therefore, primarily onto technologies. All *DEEP* participants are required to have some basic computer skills before they begin the project and this therefore will be the purpose of this workshop.
- 13 January 2002: Fine-tuning computer skills; preparation for the launch and training; meeting your facilitabrs, trainers and coord nators.

- 14 January 2002 (08h30-11h30):Official Launch of *DEEP* and Opening ceremony
- 14 January 2002-17 January 2002:Introduction to *DEEP* and Intensive Training on Project Activities
- 25 January 2002-30 August 2002:Engagement in DEEP research activities - in and out of the classroom - and interaction with partners and facilitators.

Please note

- Candidates/participants will be reimbursed for their travel expenses.
- Accommodation and meals will be provided for the duration of your stay.
- Failure by either partner to attend will nullify your participation in *DEEP*. This implies that **both educators from each school have to attend for the school to be able to participate**.
- Should there be **changes/replacements** in your school's two-person participating team, please let us know immediately.
- School principals (**who are not already candidates/participants**) are free to attend the official opening ceremony (Monday 14 Jan 08h30 - 11h30), which will be attended by the Education MEC, our international partners and other dignitaries. ***We would appreciate it if principals could indicate by the 12/12/2001 whether they will be attending.***

If you have any enquiries or would like more information feel free to contact me at the above numbers or at 082 200 4692.

We hope that you will enjoy your time with us and look forward to working together towards the upliftment of the African child.

See you soon.

Yours in Education

pp .....

Adi Kwelemtini
Project Coordinator

APPENDIX B

Data collection.

Data was collected by the author during the implementation of the programme. After each training and discussion sessions with researchers information would be stored electronically in our laptops and palm- top. Some information was collected from the DEEP report (2004)

Questionnaires

During this study, a number of questionnaires was collected and analyzed. They were written in English but teachers had to interpret in Xhosa as most of the learners are Xhosa speakers. Questionnaires were completed during our cluster meetings and some were sent to the school principals. Questionnaires were given to the project teachers to take to their learners and principals. Questionnaires were short and designed to take not more than 20 minutes. These questionnaires were focused on the experience of ICT in different contexts such as:

- classroom practice- e.g. using the ICT to support teaching in the classroom
- Professional development e.g. networking with other teachers, using software packages for developing professional skills
- Personal use e.g. finding information for personal interest, playing computer games, doing assignments etc.
- Administration e.g. monitoring pupil progress, drawing time tables, report cards etc.

The questionnaire also looked at how often these technologies are used and which ones were frequently used. .

Classroom observations

Only 10 project schools were observed during this study. Two schools couldn't be visited, one is very far and the author didn't manage due to transport problems and time factor. The second was no longer part of the project. 2 hours was spent in each

school. The palm-top and the digital camera were mainly used for classroom observations. Sometimes the video camera was used due to its availability, since it was given to teachers on a rotational basis. During this study, students were exchanged amongst the project clusters to observe how they work together and share knowledge.

Interviews

Well structured interviews were conducted in 10 project schools. These interviews were carried out during the school visits. Informal interviews were also conducted during cluster meetings and when teachers come together for planning activities.

Lesson observation

Lessons were observed on a fortnightly basis in all the clusters had to continue with visiting each other and highlight their challenges as well as their achievements. Feedback on lesson presentation was given and teachers were encouraged to share and reflect on their own experiences.

APPENDIX C

Summary of the digital technologies.

Portable computers (Laptops) - Microsoft South Africa provided all DEEP schools in the Eastern Cape with a single laptop computer. The partner teachers had to share the laptop during the period of the programme.

- Personal hand-held and digital cameras – All project teachers were provided with a 'state of the art', powerful pocket pc [206 MHz processor] and a small digital camera add –on and docking station, to facilitate their own personal study. Various science activities were installed on these devices in the form of easily accessed e-books, as educators we felt on top of the world with these types/kinds of technologies, as we among the first group of teachers to own such ICTs.
- Printer scanner and photocopier – An all in one printer- scanner and copier machine was also provided to all schools.

The adoption of hand held computer use has not eliminated the need for schools to purchase desktop machines and other hardware Marshall and Ruohonen, (1998). The all in one printer-scanner-copier machine was provided to all DEEP schools. Many useful activities are not done on the laptop alone, so that necessitates the provision of printers, scanners and other peripherals in the classroom and where possible in libraries or resource centers for use with the portable computers.

- Digital video camera

One digital video camera was provided for the project schools and they should share and was to be used on rotational basis. It is a camera that is used to capture and store images as digital (electronic) information. Images can be stored either on a memory chip in the camera, on disks or in some cases on plug-in memory cards. It was frequently used and images would be transferred to the laptop.

- Palm top computer is a relatively small computer that can actually fit into the palm of the hand.
- CD-ROM Drive refers to the device built into the computer (or external) used for reading CDs. s most software is distributed on CD-ROMs, it is important that

computers come equipped with a CD- ROM drive. IN the DEEP project they were used to save various websites such as Enchanted Learning, African Wild Life etc.

- Internet- means the vast collection of interconnected networks that all use the TCP/IP protocols and that evolved in the late 60s and early 70s. The Internet connects roughly over 100 000 independent networks into a vast globe Internet. Schools were subscribed to Imaginet (Service Provider) and only those who have electricity manage to use it. Some schools didn't have phone connections and educators were allowed to connect at their homes and down load information for the learners. Every month they were expected to submit the statements to the project coordinator.
- Personal Mobile Phone (Exceptional) teachers were using their cell phones to share information about various aspects concerning the project. These cell phones were not provided by the project.

APPENDIX D

Classroom rules

Learners from all the project schools developed classroom rules. The aim was to ensure that the available ICTs were used effectively and handled with extra care. Learners showed great responsibility and ownership of the equipment. I've consolidated all the classroom rules that were submitted and compiled one. Most of the issues raised were common in all schools such as:

1. No eating inside the classroom.
2. No drinking near the computer.
3. Do not run or play inside the room
4. Respect one another.
5. Take turns to use the computer and other ICTs
6. Listen to the group leaders
7. One person must switch on and off the computer before and after use and the others must observe
8. Make sure you don't triple over the chords of the battery
9. Put the computer back in its carrier bag after use.
10. Avoid bumping and banging the computer when not used.
11. Fold the charger properly and don't leave it on while computer is not in use.
12. Never wipe a computer screen with wet cloth and avoid abrasive chemicals.

APPENDIX E

Cluster Meeting agenda- 15 September 2005

The agenda was distributed to three clusters that are existed within the project.

Aim of the meeting

- To discuss the impact of ICT in teaching and learning
- To identify factors that are affecting the use of ICT in teaching and learning
- To share experiences on how we have used the iPAQs for teaching and learning.

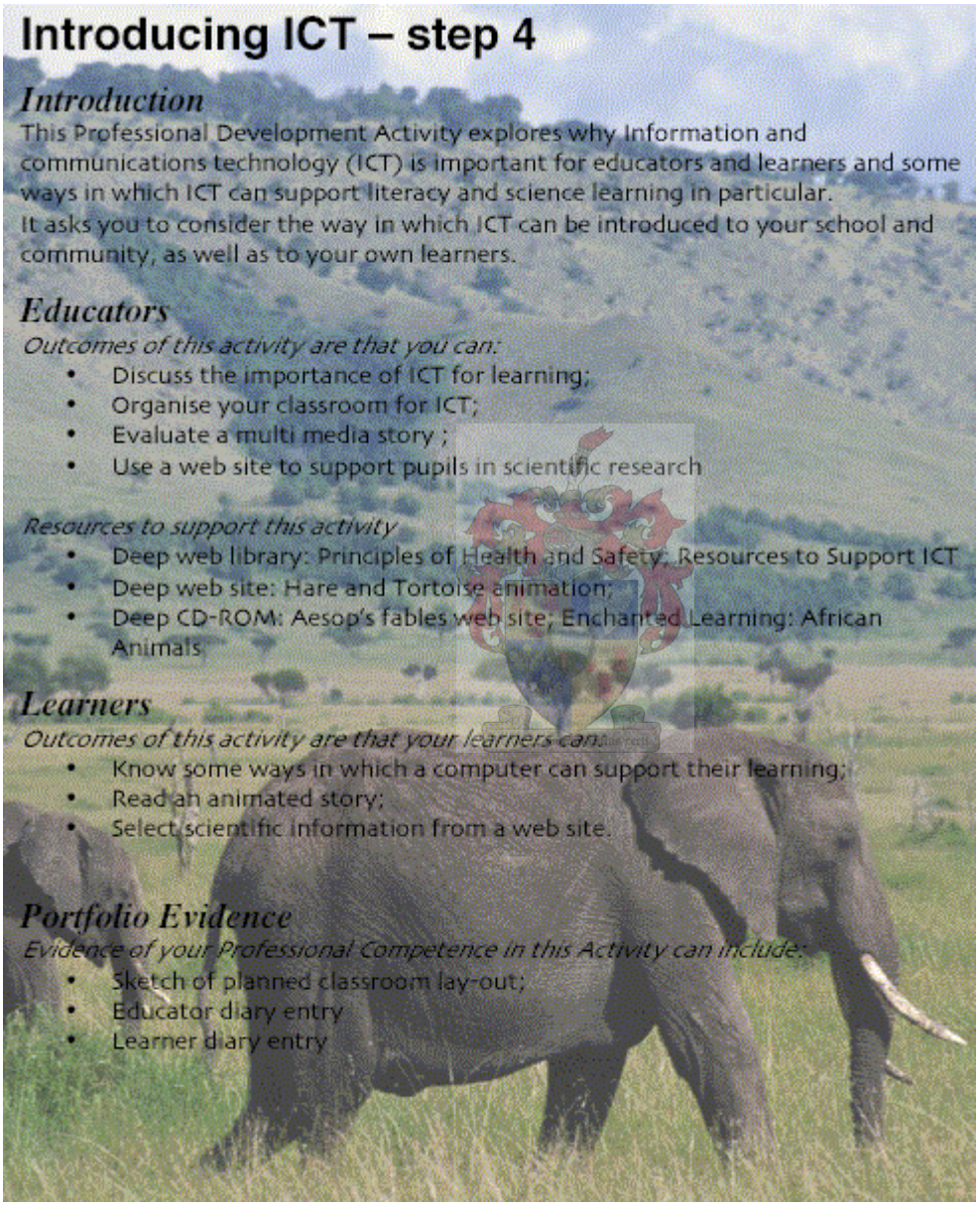
To find out:

- teachers' beliefs about how learners learn with ICT
  - How do learners learn in the new ICT environment?
  - What type of knowledge, skills and attitudes are best developed through this type of use?
  - What is the role of the learners in a classroom situation?
  - Do you have supporting evidence that shows that learners when using ICT in a particular way?
- how teachers can apply a range of ICT strategies to support learning and teaching?

  -What kind of training, skills and knowledge does the teacher need?
- What are the main barriers that affected the use of ICT?
  - How have you overcome these barriers?
- Identify factors that facilitate or inhibit the use of ICT.
- How teacher identities have been affected by ICT?

APPENDIX F

A sample of activity cards that was used for teaching Science: Life and Living.



APPENDIX G

Interview form

Teacher name	Date:
School	Resource used
Interviewer:	

Summary of interview (including any comments on any non-verbal information received

Topics discussed vary depending on the person that is interviewed. Te interview is mainly about the impact of ICT in teaching and learning.

Lesson Theme (teachers only)	Date
Type of ICT use	Class
Impact of ICT on whole school (Principal	Year

APPENDIX H

Lesson observation pro forma

School Name	Date
Teacher name	Grade
Observer	
Lesson Theme:	
ICT Resources used (including software details)	
Overall impression of the lesson:	

Classroom arrangement/organization

No of groups	
No of learners per group	
Pairs	
No of pairs	
Whole class teaching	

Documents collected

Document no	Document name	Document description	Teacher comments on documents

General comments

GLOSSARY OF TERMS

CD-ROM	Computer storage medium that contains a range of data stored digitally, such as words, graphics and sounds. These can store up to 250,000
Digital divide	The gap between those who have computers and those who do not, as well as the gap between those who are computer literate and those who are not.
Digital camera	A camera which captures and stores images as digital (electronic) information. Images can be stored either on a memory chip in the camera, on disks or in some cases on plug-in memory cards.
e-Education	It revolves around the use of ICTs to accelerate the achievement of national education goals. E-education is about connecting learners and teachers to each other and to professional support services, and providing platforms for learning.
E-mail	Electronic mail, messages sent and retrieved in electronic form via computers.
Encarta	A multimedia educational information resource. IT comprise a set of CDs which essentially like an electronic encyclopedia.
Information and communication technology	The technologies which together support people's ability to manage and communicate information electronically. They include not only computers, but also such technology as digital cameras, video recorders, television and radio.
Information technology	IT is short for Information Technology is the broad subject concerned with all aspects of managing and processing information, especially within a large organization.
Internet	The vast collection of interconnected networks that

	all use the TCP/ IP protocols and that evolved in the late 60s and early 70s. Internet roughly connects over 100 000 independent networks
Laptop computer	Portable computer, small enough to carry around and use on your lap
Login	The username used to gain access to a computer system. This is not secret, in contrast to a password.
PDA	Personal digital assistant device
Portal	Web portal- commonly referred to as simply a website or service that offers an broad range of resources and services, such as discussion forums.
PowerPoint	A software package developed specifically for facilitating the development of presentations. (such as presentations can be viewed on the computer monitor or projected onto a screen with the use of data projector.
Scanner	Device by which hard copy pictures and text can be converted into digital form for use on a computer. Scanners can also be used to read bar codes and convert them into numerical data.
World Wide Web	or simply the web. a distributed information service on the Internet of linked hypertext documents accessed using the web browser such as Microsoft Internet Explorer or Netscape. On the web, any document can be linked to any other document.