



## **4D Technologies for Teachers: investigating the use of ICT by the rural poor in Eastern Province, South Africa.**

Jenny Leach and Shumi Makalima  
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Shumi Makalima  
DEEP Coordinator  
University of Fort Hare  
Private Bag X7488,  
King Williams Town,  
5600 RSA,  
South Africa  
Tel: + 27 21 448 9165  
E-mail:shumi@telkomsa.net

Jenny Leach  
Research Group on International  
Development in Teacher  
Education across Cultures and Societies  
(RITES)  
The Open University  
Stuart Hall Building, Level 3  
Walton Hall  
Milton Keynes  
MK7 6AA  
Tel: + 44 (0)1908 652444  
Fax: + 44 (0)1908 652218  
E-mail:j.leach@open.ac.uk

**DEEP Web Site <http://www.open.ac.uk/deep>**

## INTRODUCTION

*‘How are we going to overcome poverty? ..... perhaps the answer lies in our ability to replicate the best elements of our society, at all levels, and among all communities.’*  
(Nelson Mandela, 1999).

‘As the sun breaks over the furthest rim of hills at Qunu, it illuminates a world apart, an idyll in the city dweller’s mind of quietitude, of lowing cattle, smoke rising in the still morning air, vivid bird calls in the waking bush, a river gleaming and silent. But being there is different. Being there is not romantic. To be there is to be engaged in a struggle to live and hope. Money and jobs are scarce. The land itself is harsh and demanding. And the schools, which straddle old rural routines and the glittering prospect of a different life heralded by political, economic and technological change in the far away cities, are most often ill-equipped, under resourced and poorly staffed. Rural people know this. Their yearning for improvements in schooling [is great].’  
(Nelson Mandela Foundation, 2005, P.2).

The research reported in this paper arises out of a number of educational activities and interventions carried out in a partnership between the University of Fort Hare (UFH), the Open University, (UK) and the Nelson Mandela Foundation’s (NMF) Unit for Rural Schooling and Development (URSD), in relation to new information and communication technologies (ICT)<sup>i</sup>. Two overarching research questions are informing this ongoing work:

- Is there a role for ICT in rural schooling and development?
- If so, what is it?

The purpose in asking these questions and developing the ideas set out in this paper is:

- to better understand how ICT can serve the educational and development goals of (specifically) rural schools and their communities in the Eastern Cape;
- to generate an action agenda that further explores how technology enhanced learning might contribute toward quality education and community development in the Eastern Cape
- to share knowledge arising from this research with practitioners and policy makers in the Eastern Cape, in South Africa and other researchers and educators further a field.

This paper sets out

- a review of the Eastern Cape context, including a survey of current ICT use and provision in rural schools;
- an account of the Digital Education Enhancement Project (DEEP), an applied research project exploring technology enhanced professional development in remote and resource challenged environments;
- implications of this research for policy and practice

## EMAPHANDLENI<sup>ii</sup>: NEW TECHNOLOGIES, NEW POSSIBILITIES

*'We must continue the fight for liberation against poverty, against under-development, against marginalization...information and communication technology...is a critically important tool in that struggle...'* (Imbizo for Africa Youth, 2001)

### The rural challenge

In the research reported here, rural teachers and their communities are placed centre stage. In particular we have been trying to represent as far as possible the experiences - fragments of success, failures and insights – of teachers engaging with new technologies for the first time. There is a dearth of research on the application of ICT to teaching and learning in developing country contexts, specifically in rural schools. In addition there are currently few, if any, examples of planned investigations into how mobile technologies can be used to support teacher education in sub-Saharan Africa. Reports on ICT work specifically orientated to rural regions, where they exist have focused on functional, procedural, technical and training issues.

During this ongoing work we have been struck by how many adults and children we talk to make no distinction between basic physical needs such as clean water, sanitation and nutrition and the desire for better educational opportunities. Access to ICT ('computers') is seen as part and parcel of the yearning for a modern (and for teachers 'professional') and easier daily life. During research into rural schooling carried out by the Nelson Mandela Foundation (2005), a primary age girl from Bizana began with 'computers' in her list of needs for school improvement - as if somehow they sum up the essential link she goes on to make between good teaching/resources and quality learning/self esteem:

*"At this school we want computers.*

*Our hair must not be cut and we must not be beaten. There should be electricity and playing grounds for rugby, volleyball, netball, soccer and softball. We also want school uniforms and electricity. Each class must have its own cupboard. Our school must be extended to Standard 7. The clinic must be nearer. We also want water tanks like in other schools. Teachers must not sit down when they teach, except in the staff room.*

*We need a timetable"*. (NMF, *ibid*, p.20)



Similar aspirations have strongly emerged in discussions with teachers, learners, community leaders and parents about new information and communication technologies. Many of those we talked to see ICT as an important means of change – one way of making rural life contemporary and up to date. Even in communities where ICT has already been established in some form, but failed thus far to live up to expectations, hopes remain high. In this sense ‘computers’ represent for some the promise of new forms of knowledge, new means of communication and a new sense of dignity and worth.

Others we meet fear and distrust ICT. It represents a threat to established ways of life, trusted routines and deeply valued culture, a potential imposition from ‘outside’. And most importantly an unnecessary drain on already terribly overstretched resources.

### **Eastern Cape context**

South Africa is a middle income country, however the provincial share of the poverty gap within South Africa <sup>iii</sup>nationally is greatest by far in Eastern Cape <sup>iv</sup>, making that region comparable to some of the poorest countries of Sub Saharan Africa (e.g. Ghana, Rwanda and Kenya). Whilst South Africa’s GDP per head is \$2,500, within the Eastern Cape it falls to \$432. Even that figure is a glib average that masks the intense poverty and deprivation of the remoter corners of the province, where many live below the poverty line. ‘The most profound challenges to South Africa’s development and democracy’ writes Nelson Mandela ‘ can be found in its rural hinterlands. These areas, systematically and intentionally deprived of the most basic resources under apartheid, continue to lag behind the rest of the country in the post-apartheid era. Foremost among the challenges facing rural South Africa is the task of improving the quality of education’ (Nelson Mandela Foundation, 2005, p.vii).

#### *ICT access and use*

In terms of access to and use of new forms of ICT the picture remains the same. Across South Africa as a whole there are 72.6 computers and 410.5 fixed line and mobile telephones for every 1000 of the population and 3.1 million Internet users. However, most of these resources are concentrated in urban areas. Some rich suburbs for instance, have 70 phones per 100 people. In the remoter parts of the Eastern Cape this statistic falls as low as 0.1 per 1000 people – the same is true for access to PCs (Accenture, 2001).

#### *A changing landscape*

Recent statistics and current experience suggests that this picture is already much changed. Across Africa generally, the technological context is developing fast, even in rural contexts. South Africa is no exception to this (see also Dladla and Moon, 2006 in this symposium). Such change is illustrated by a survey of teachers in rural schools in the Eastern Cape that was carried out October 2005 (Figure 3).

**Figure 1 Teachers' Use of Technology: Eastern Cape November 2005 No=35**

TECHNOLOGY	No. used before (%)	No. never used before (5)
Computer	29 (82%)	6 (17%)
Mobile Phone	33 (94%)	2 (6%)
Television	34 (97%)	1 (3%)
Radio	32 (91%)	3 (9%)
Internet	17 (49%)	18 (51%)

The survey was carried out with teachers working in schools with exceptional computer provision, therefore the fact that the majority of these teachers (29: 82%) report experience of desk top computers is unremarkable. Nevertheless, more than half of these teachers also reported that they have access to a computer outside of school (20: 57%) and 8 (22%) own their own computer. Use outside of school includes "access to a friend's computer" (14%:5), through Unitra Community Radio Service(1), at Internet Cafes (4) and for study at Walter Sisulu University (1) and ITEC(1). Most of those using their own computers and/or with experience of lap top use are in the younger, 20-29 age group.

The majority of teachers also had 'some' or 'a lot' of experience of TV (35:97%), Radio (32.91%) and Cell Phone use (33.94%). This high report of cell phone use (33:94%) mirrors what we know about the adoption rate generally of mobile technologies in Africa's developing countries. It is now amongst the highest rates globally; forecasts estimate almost 100 million mobile users in Africa by 2005 (Shapshak, 2002). The number of mobile subscribers in Africa increased by over 1000% between 1998 and 2003 to reach 51.8 million (ITU, 2004). And although the figures and statistics for 2005 are not readily available at this point in time, they are likely to be much higher than expected. It is increasingly clear that the adoption rate of mobile technologies is exceptional in Africa. The continent is leapfrogging from an unwired, nonexistent technology-enhanced infrastructure to a wireless infrastructure. Thus whilst the gap between urban & rural South Africa in terms of access, connectivity and technology use remains significant, research is suggesting two things are rapidly changing with respect to context:

- mobile networks are increasing dramatically
- knowledge of and use of ICT especially cell phones, but also of the internet, imaging and computing more generally is increasing, especially amongst younger age groups.

Investment in ICT in South Africa, including in education, is also growing sharply (Fig 2). In 2001 \$11,430,000,000 was invested in ICT (5.7% of GDP). Power (2006 forthcoming) notes this represents an average spending on ICT of \$268.7 for every person living in the country.

**Figure 2 Growth in PC use, South Africa**

ICT indication	South Africa	
	1995	2001
PCs per 1,000 people	27.9	68.5
PCs installed in education	92,800	364,700

Internet accounts	460,000	3,068,000
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*Government policy and provincial plans for E-Education*

South Africa's first White Paper on Education and the National Education Policy act of 1994 set out its intention to 'redress the imbalances of the past through the implementation of new teaching and learning strategies (...) flexible delivery of services and the equitable distribution of technological and other resources'. A decade later, this broad and ambitious agenda has been formalized in the White Paper on E-Education: Transforming learning and teaching through Information and communication technologies' (South African Department of Education, 2005). The paper sets out 'a new framework for the collaboration of government and the private sector in the provision of ICTs in education' and summarises the challenge of rolling out infrastructure that is specifically suited to Africa. Through appropriate technologies 'it is hoped that South Africa will leapfrog into the new century. By passing the unnecessary adoption cycles, and implement a solution that works now, and has the capacity to handle future developments'.

Whilst the Eastern Cape Province is committed to implementing the government's e-education policy and making use of these new forms of content provision and national training, the challenges it faces in so doing are enormous. Aside from huge inequities of provision between rural and urban areas and the worst poverty in South Africa in the former Transkei, as set out earlier, the province has also inherited:

- the largest provincial schooling system in South Africa
- very low current provision of ICT in schools. (In 2002, 8.8% of schools had computers and only 4.5% were using computers for teaching and learning).



Other obvious challenges in implementing any conventional e- education policy are:

- the highest classroom backlog in the country. (In 2003 Eastern Cape needed to replace 9,835 mud classrooms and build 14,970 new ones);
- Many schools still without electricity. (In 2003, 49% of schools had grid connections, 21% generators or solar power, 30% had no power).

- Low telephone provision. (In 2003 a third of all schools had a fixed line connection).

## THE DIGITAL EDUCATION ENHANCEMENT PROJECT

### Aims, principles and key research questions

Against this background, The Digital Education Enhancement Project (DEEP) is investigating the potential of technology enhanced teacher development (<http://www.open.ac.uk/deep>). DEEP's aim is to contribute to the growing, but as yet relatively small number of in-depth research studies intended to inform policy makers, educational researchers and others interested in ways in which the use of ICT can enhance teachers' capabilities, improve knowledge and professionalism and hence contribute to the aims of the Education For All (EFA) agenda ([http://portal.unesco.org/education/en/ev.php-URL\\_ID=35939&URL\\_DO=DO\\_TOPIC&URL\\_SECTION=201.html](http://portal.unesco.org/education/en/ev.php-URL_ID=35939&URL_DO=DO_TOPIC&URL_SECTION=201.html) 17/2/06 ). The project focuses upon two, interrelated research questions:

- How does Information and Communications Technology (ICT) transform the pedagogic knowledge and practice of teachers and the communities in which they live and work?
- What is the impact of ICT- enhanced strategies on pupil achievement and motivation?

### Overview of the project

Inkanyezi [glowworm<sup>v</sup>] is the Xhosa name for the DEEP programme as it has been implemented in the Eastern Cape Province. The work has been funded by the Department for International Development [DFID], Microsoft SA, Hewlett Packard and bridges.org. This programme was initially implemented between January 2001-March 2004 in 12 primary schools, with 24 teachers (two per school) and over 1,000 pupils in the 9–13 age range<sup>vi</sup>. It focused particularly on the teaching and learning of literacy, numeracy and science (Leach, Klaas, Mnqgibisa, Power, 2002). Participating teachers worked in pairs to carry out and evaluate a sequence of technology enhanced, curriculum focused, professional development activities. These included classroom activities to be carried out with chosen classes. Teachers were provided with high quality, multi-media materials including classroom resources and local support.

#### *Research design and theoretical framework*

The research team aimed to capture trends across the DEEP project as they emerged over time. Our task was to document the processes through which participating teachers were introduced to a range of uses of ICT for teaching and learning and then to try and capture the types and qualities of ICT use (if indeed there was any) in their daily lives.

A range of data was gathered by the research team across the two year period, including questionnaires, diaries, interviews, classroom observations (including video), teachers' concept maps, laptop histories together with electronic 'products' made by teachers, pupils and members of the community. School principals and many

pupils, parents and other members of the community actively participated in the research process.

Four key principles were elaborated by the project team in order to help us to understand and document the experiences of teachers, students and communities learning to use unfamiliar technologies for the first time (see Leach, 2006, p. 27):

*First:* Teacher learning and development are social processes - as much participatory processes, in the sense of people jointly constructing knowledge within particular groups, workplaces or communities, as of individual development (e.g. Lave and Wenger, 1991).

*Second:* Teacher learning is always a situated and active experience - people are in essence agentic (Sen, 1999), proactive, intentionally focused (Bruner, 1996) on the purposes of the communities to which they belong

*Third:* A social perspective calls attention to the recognition that the practices of teacher learning have no physical boundaries. It enables attention to be paid to the impact that the classroom, wider school and community have on the process of teacher and student learning, as well as the important role outsiders can play in communities when communication technologies are being used

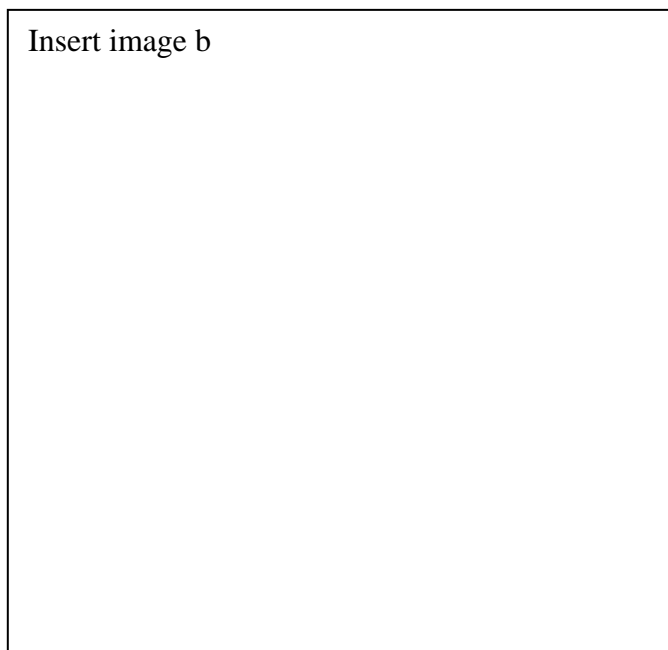
*Fourth:* Technology is an essential component of human agency - culture provides the 'toolkit' of technologies, techniques and procedures with which different groups and communities learn about, respond to, act on and manage their experience of the world (Bruner, 1996)

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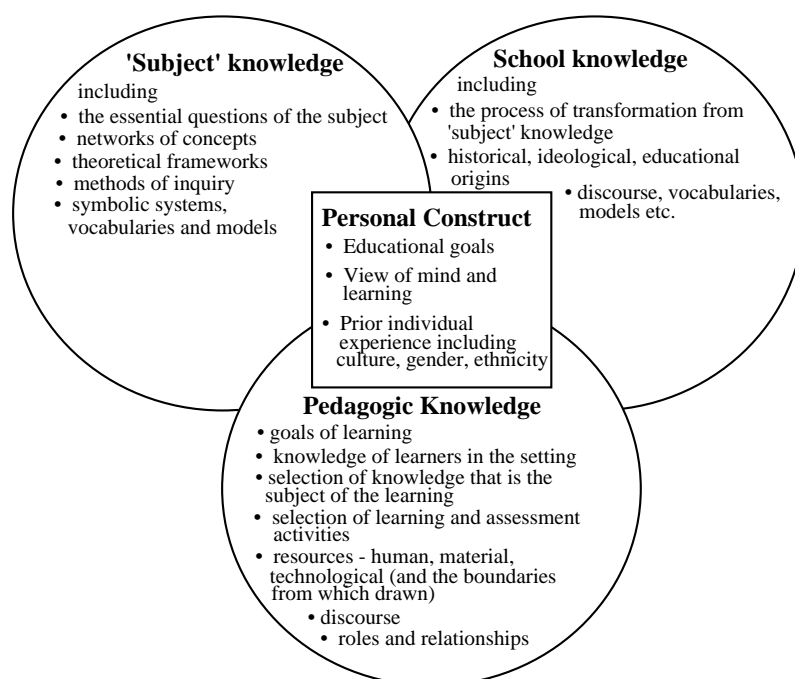
This fourth principle is key to the DEEP project's philosophy and aims. By our very human being, Bruner eloquently argues we are also constrained. The limits of our mental predispositions can only be transcended by our uses of more powerful symbolic systems such as language and notations and also importantly, by our uses of human tools, technologies and related artefacts. These include the devices that enable us to store and manipulate the vast accumulation of human knowledge, critical to all our daily activities, 'standing on the shoulders of those who preceded us.' (Bruner, *ibid.*, p.18). In this very deep sense, our contemporary knowledge, understanding and forms of meaning making depend on the cultural toolkits we have at our disposal. If pedagogy is to empower human beings then 'it must transmit the 'toolkit' the culture has developed for doing so' (p.17). The myriad, often taken for granted artefacts of educational settings – be they libraries, pens, abacuses, calculators, sports, music or science specific technologies, computers, or sophisticated electronic data bases and statistical tools – all serve to potentially extend the reach of activity and learning in one way or another. Including the practice of being a teacher.

An existing model of teacher professional knowledge (Figure 3, Banks, Leach and Moon, 1999) has been used within the DEEP research design as a means to understand and analyse changes in teachers' thinking and practices as they worked with new forms of tools and technologies – an extended toolkit of practice. The model is derived from the work of Lee Shulman (Shulman 1987), but goes beyond his ideas in taking account of the highly contextualized nature of knowledge building and learning within educational communities. It emphasizes the multiple identities of teachers within their school communities: as subject experts (*subject* knowledge); as subject teachers (*school* knowledge); as teachers (*pedagogic* knowledge). At the centre of this interpretation lie the teachers' personal identities (*personal* construct), always developed within a range of other, overlapping groups and communities (e.g. mother, friend, musician, baseball player, Muslim, Xhosa speaker etc).



This representation of teacher knowledge we judged would enable us to map what the implications might be for the teachers within the project when introduced to ICT. The categories of knowledge were used throughout the study as a means of categorizing and interpreting teacher related data, as well as a way of documenting change. They are also used as a theoretical frame within this paper.

**Figure 3 A model of teacher professional knowledge (Banks, Moon and Leach, 1999)**



### *Participating schools*

All schools in the project serve disadvantaged groups. Most of the Eastern Cape schools (which are the particular focus of this paper) are situated in rural settings that can only be reached by several hours' drive on unmade roads – these local communities and their teachers had never experienced computer technologies. Six of the schools have no electricity and five no telephone connectivity, although a mobile network can be accessed by all schools and at least one teacher in each owns a cell phone.

### **Project participants' prior knowledge and experience of ICT**

The majority of teachers had been teaching for a minimum of 3 years but few had been involved in any professional development programme, either for the development of subject or of pedagogic knowledge. Teacher's ICT knowledge was very different to the more recent teacher profile set out Figure 1. 14: 58% had never used a computer prior to the project, whilst the majority (18: 75%) had never used the Internet and none owned a computer. Of the 10 teachers who had prior experience of computers, 5 had 'occasionally' used them in relation to teaching; 4 of the 5 were based in the project's town schools. The other 5 had 'occasionally' used a computer at an Internet or study centre, or with a friend, but never for teaching. Previous applications of the technology were overwhelmingly for 'personal use' (21: 87.5%).

**Figure 4 Teachers' Prior use of technology: Eastern Cape January 2002 No=24**

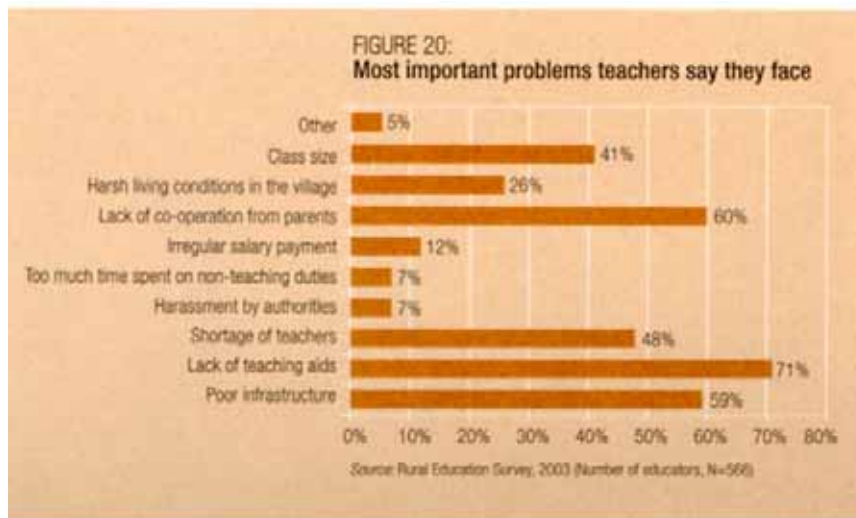
TECHNOLOGY	No. used before (%)	No. never used before (5)
Computer	10 (43.5)	14 (58.3)
Mobile Phone	15 (71.4)	6 (28.6)
Television	21 (87.5)	3 (12.5)
Radio	19 (82.6)	4 (17.4)
Internet	6 (27.3)	18 (75.0)

In the remote locations where most of these teachers live and work, unemployment is high, agricultural opportunities limited and resources scarce. Schools have negligible resources, apart from a small number of books and artefacts (generally created out of carefully salvaged waste) to support basic numeracy and science work, such as beakers, cardboard boxes, bottles and bottle tops. Classrooms generally have poor natural lighting and fragile furnishings. None are heated, although temperatures can fall below zero in the high ground during winter and many have no windows. Three of the schools' classrooms have dirt floors and children sometimes have to stand during lessons because there are not enough desks or chairs.

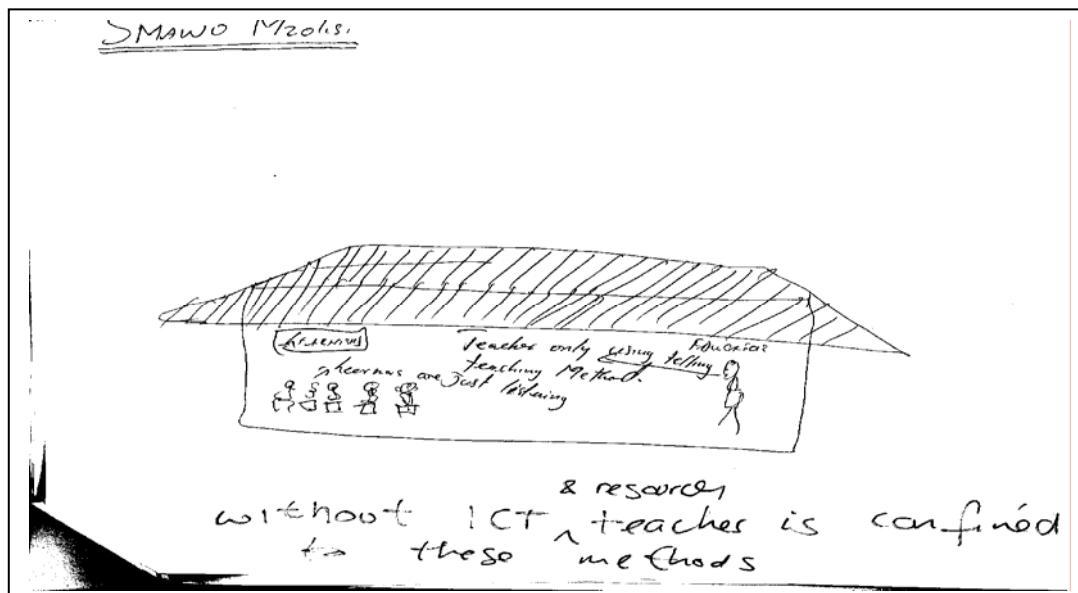
This context means that teachers in rural schools have no routine access to professional artefacts of any kind, let alone the technologies that many teachers in other parts of the world take for granted (e.g. planning templates; up to date pedagogic ideas; photocopiers; reference materials, example lesson approaches; dictionaries; thesaurus; well-resourced libraries). The DEEP study revealed just how exhausting and de-motivating it can be for teachers to maintain the intellectually demanding work of teaching day after day with large classes, without a proper professional toolkit. Teachers were outspoken about the limitations and restrictions of their knowledge base - especially as they became used to a more sophisticated and broader professional toolkit. Appendix 1 sets out what resources a teacher typically might be able to access, together with the kinds of professional development they would afford. One DEEP school was using such meagre resources (especially a small school library donated by the USAID's READ project) to creatively develop a range of innovative pedagogies prior to the project. Teachers described the daily grind of commuting to work (one and a half hours each way) by train, 'taxi', thence on foot, only to face large classes with the minimal of resources to enable them to set up this work *'Everyday we arrived to write 'the lesson for the day' on the board. The next day we rubbed it out and started again. No work could be saved. They (the students) often couldn't read my writing'*.

The NMF study verifies this harsh picture of rural teaching 'Lack of teaching aids' was seen by the majority of rural teachers interviewed for the *Emerging Voices* study as the most important problem teachers faced (71%), more so than irregular salary (12%), harassment by authorities (7%), class sizes (41%), harsh living conditions (26%), other duties (7%), teacher shortages (48%), and poor infrastructure(59%) (Figure 20, NMF, *ibid*, p.84, Figure 5 below).

**Figure 5. Most important problem teachers say they face** (NMF, 2005. page 84)



**Figure 6. Teacher's cartoon of her classroom**



Teachers intuit that ICT might provide a range of resources, practical approaches and subject aids that they long for in order to make their teaching more effective. The cartoon above (Figure 6) encapsulates this view *'Teacher only telling and learners just listening; without ICT and resources teacher is confined to these methods'*.

### **The DEEP Professional Toolkit**

#### *The ICT Resources*

An 'ICT Toolkit' was assigned to each participating primary school/teacher pair primarily designed to facilitate professional learning including classroom use. It was intended this toolkit should be easy and flexible to use in a variety of settings, creating minimum physical disruption to the school environment. The many strengths of using mobile devices (such as laptops and handhelds) rather than fixed desk top computers in harsh rural contexts are set out in Appendix 2.

**Professional ICT Toolkit** (for use by project partners in primary schools, Eastern Cape)

- ❑ Shared lap-top for classroom use (with CD-ROM, Internet access, support for current generation software, microphone and speakers)
- ❑ Project website & e-resources
- ❑ All-in-one printer-scanner-photocopier
- ❑ Allocation of ink; paper; personal e-mail account with ISP; small budget for Internet connection
- ❑ Individual hand-held computer with digital camera and docking station
- ❑ Software including: reference software; atlas; curriculum software; productivity software and project CD-ROM
- ❑ Access to project digital camcorder (shared by the 12 schools)

In conceptualizing these digital resources, the research team had been guided by the new forms of activity and teacher knowledge - '*subject*', '*school*', '*pedagogic*' and '*personal*' (Figure 4) it hoped might be developed by project teachers. Rather than starting with questions about hardware and software (e.g. 'How many computers / computer suites?', 'How many can we afford?', 'What infrastructures are needed?') DEEP took a broad view of teacher knowledge and pupil learning and how an ICT toolkit might support its development. Appendix 2 sets out the many new professional opportunities it was hoped the technologies would support. For example, in order to develop teachers':

- *subject knowledge*, provision of resources detailed and broad enough to support professional enquiry was required (e.g. Internet access to a range of high quality, subject-focused multimedia resources related to the project's content). Where internet access was fragile, or in some cases non-existent, CD (or DVD) – ROMs would provide alternative, albeit more limited, access to quality information and data;
- *pedagogic knowledge*, required one display large enough for several pupils or teachers to be able to see a computer screen at one time so they could work together collaboratively. Multimedia can enhance the way learners research a topic, and present their findings to others, therefore support for sound, animation and video is also seen as highly advantageous;
- *school knowledge*, demands access to classroom planning and resources, exemplar curriculum activities, as well as to professional networks and tools that facilitate the sharing of practice;
- *personal development and confidence* ideally required mobile devices that would allow for portability and the opportunity for teachers to 'tinker' and 'play' with ICT, as well as to make mistakes in private<sup>vii</sup>. Teachers needed access to ICT across a wide variety of settings [ e.g. in classroom, teacher meetings, at home].

The modest devices provided participating schools with access to an extraordinarily powerful and mobile '*pocket classroom*', usable in a myriad of settings. One hand held computer, for instance, enables access to e-books, a thesaurus, dictionary, notebook, diary, Xhosa Bible, work books, curriculum materials, games and puzzles, planners and student resources. The lap top can store a range of additional artefacts of practice: planning tools, captured web sites including multi-media case studies of effective subject teaching; model schemes of work; approaches to classroom organisation with large class sizes and so forth.

### *The Professional development activities and resources*

A cycle of Professional Activities incorporating new *subject* and *pedagogic* knowledge, was designed to prepare teachers to try out and evaluate a range of Classroom Tasks with their students (Fig 7). It was planned that teachers would work together in pairs throughout the programme, carrying out and evaluating these Professional Activities collaboratively. These pairings were seen from the outset as an essential aspect of the support framework, reflecting the notion of joint knowledge building, a key principle of the conceptual framework set out above. A sharing of study activities and resources was encouraged, as was the development of a common portfolio.

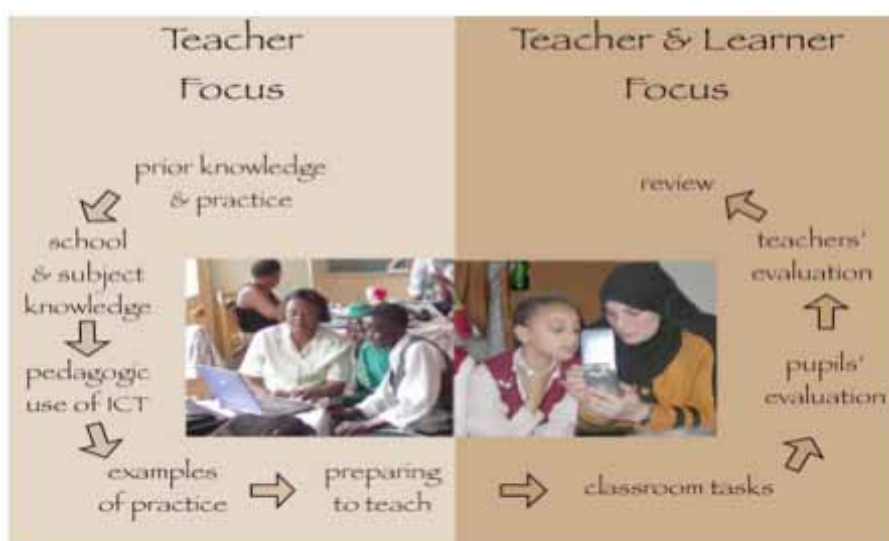


Figure 7. Cycle of Professional Activities

A locally relevant environmental theme, (Endangered Animals) modelled a range of literacy, numeracy and science-focused professional Activities. Resources to support these included: a print-based teacher guide; specially designed CD-ROM resources, incorporating a range of related lesson plans, case studies, stories, video clips and websites; a programme website providing the CD-ROM resources on-line, also incorporating a discussion area); a school portfolio, comprising folder and blank floppy disc for gathering evidence of teacher and student outcomes. Activity cards were also developed some three months into the programme summarizing the DEEP professional development Activities. This common framework allowed for increasingly demanding classroom activity, as teachers progressed in confidence e.g. from simple literacy word processing and web search activities about local animal species, to the e-mailing of research findings to students in other schools.

### **Headline findings**

Full details of the research methodology and programme outcomes are set out in the project report (Leach, 2006). In summary, all project teachers and their students

quickly developed confidence in using the ICT Toolkit for a range of purposes. The report notes that:

- Development of basic computer skills was largely unproblematic both for teachers and their pupils;
- ICT use enhanced teachers' professional knowledge and capability by: extending subject knowledge; enabling planning and preparation for teaching to be more efficient; developing the range of teachers' existing pedagogic practices;
- Every teacher introduced ICT into planned lessons with their classes and there was wide ranging evidence of positive outcomes;
- Students used ICT to carry out a range of literacy, numeracy and scientific activities and there were outcomes: students showed high levels of motivation in using ICT both within and out of lessons; a range of achievements, including improvements in literacy and science learning, were reported by teachers, school principals, parents – and students themselves.

Teachers, together with parents, governors, school principals and community members reported that use of new technologies had positive effects on areas central to Universal Primary Education (UPE), including attendance, motivation and the quality of student learning. The professional status, self esteem and dignity of teachers was also enhanced within their immediate communities and more broadly in the societies they serve.

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## DISCUSSION

### Developing subject knowledge

'In poor communities, the scarcity of trained local personnel and the impediments they face in accessing vital information and enhancing their skills, perpetuate the low educational attainment and poor health of these communities and makes them less able to cope with new challenges'. (Marker et al., 2002, p. 7)

ICT use enhanced teachers' professional knowledge and capability by extending subject knowledge.

The development of subject knowledge, as set out in the model of professional knowledge was the most frequently cited purpose for teachers' own professional use of ICT, both in interviews and questionnaires (29: 82%, Exit Questionnaire). Subject knowledge was also the aspect of professional knowledge that teachers deemed the project to have had the highest impact on: 'The DEEP had a great effect on my abilities in teaching my subject and made me enjoy it more'; 'I have started to use computers in away that is related to my speciality.' (Exit Questionnaires). Research more generally suggests that teachers' subject knowledge is an essential component of effective teaching, yet it is an element of continuing professional development often overlooked, or taught in isolation from other aspects of professional knowledge. The approach taken in DEEP to integrate subject matter development in tandem with new pedagogic knowledge supported by ICT, through the planning, teaching and evaluation of classroom-based activities was welcomed by teachers. Teachers requested that additional cross-curricular themes such as health and citizenship should also be developed by the programme that could support literacy, numeracy and science teaching, much as the environmental theme had done.

### Developing school knowledge

*"I can't go into a class now without having planned activities thoroughly"*  
(Teacher interview)

*"Now I come to feel creative"*(Teacher interview)

ICT use enhanced teachers' professional knowledge and capability by enabling planning and preparation for teaching to be more efficient

Within the model of professional knowledge the category 'school knowledge' is used to gain a hold on the complex processes a teacher must carry out to transform subject matter of any kind into teachable form, taking account for example of age groups, interests and prior experience. 'School knowledge' includes: knowledge of national curricula; the discourse, vocabularies and models of school subjects; understanding of national examination criteria; as well as how to translate all these into meaningful, progressive schemes of work and lesson plans and thence into practice. The findings of the study unexpectedly revealed the key role ICT can play in supporting the development of school knowledge and hence a new sense of professionalism. In both



contexts teachers reported that use of ICT had impacted on their ability to plan lessons; a majority (27: 77%) reported 'high' impact.

The most frequent uses of ICT for the development of school knowledge were:

- *to obtain resources* (27:77%);
- *to prepare teaching materials* (22: 62%);
- *to prepare lessons* (22: 62%);
- *to produce teaching resources* (18: 51.5%);
- *administration* (12: 34%) Exit Questionnaires,

Teachers particularly reported on the expansion of their professional capabilities as they used and got used to the laptop and/or hand-held computer. Many considered that there was something unique about the opportunities provided by such flexible, mobile devices in their particular context. Appendix 2 documents these. Portable computing offered new possibilities in terms of access to 'anytime, anywhere' professional activity: the computers could be used at home, in the classroom, in friends' homes, on fieldtrips or at a special event. In both contexts the use of the word 'creative' was frequently chosen by teachers to describe how they felt about the way ICT had changed day-to-day classroom organization and planning activity. Through new opportunities to practice the planning process, amend model lesson templates, explore video and case studies of collaborative learning, access and develop fresh resources, teachers in the project, felt motivated and confident enough to try out new teaching strategies.

Such findings challenge current orthodoxy that ICT relegates the teachers' role to that of 'facilitator', confirming research that shows teachers' expertise and creativity in planning for pedagogy to be a central element of effective practice. More broadly they highlight the importance of school knowledge for effective teaching and the key role ICT can play in its development, enabling teachers to plan and develop resources and teaching strategies highly effectively and creatively. ICT enabled participating teachers wherever they were situated to access, use, develop and improve some of the essential artefacts of their practice: planning tools, case studies of effective subject teaching; model schemes of work; approaches to classroom organisation with large class sizes and so forth.

### **Developing pedagogic knowledge**

*'We are writing our own African story'. '...We even made drawings..' 'I've learnt how to sketch...' 'I learnt to scan..I have learnt how to improve a picture on the computer...' 'I find it very interesting to work with a computer... I've learnt how to print and type on the computer...' 'The story is about how the giraffe got its long neck. We will share the story with all of you when it is done...' ' E-mail from members of Grade 7 class members, Uxolo School*

ICT use extended the range of teachers' existing pedagogic practices: all teachers introduced ICT into planned lessons with their classes; there was evidence of students' outcomes from these lessons.
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The majority of teachers reported that they considered ICT to be 'important' or 'very important' for teaching and learning; 88% of teachers in the Eastern Cape considered

it to be ‘very important’ (Mid- and end of project questionnaires). Although the research team expected the DEEP Professional Activities would stimulate some new classroom practice, classroom application was not expected until the second term of the project. It was an unexpected finding that all project teachers were using ICT in the classroom by mid-project review. In the Eastern Cape, most teachers had been integrating ICT into some lessons, some two months after project launch.

Project teachers identified their most frequent, use of ICT within the classroom as:

- *to facilitate collaborative working* (74%);
- *to present material* (54%);
- *to enable independent learning* (31%).



Reports on student use of ICT within the classroom were extremely varied. The majority of teachers stated that students used computers to ‘access information’. Other uses fell into the following categories based on qualitative responses to the end of project questionnaire:

*Individual & group use*

- ‘individual investigation’;
- ‘group investigations’;

*Generic skills and processes*

- ‘research’;
- ‘to practice ICT skills’;
- ‘working on spreadsheets’;
- ‘to present material’;
- ‘for problem solving’;
- ‘photography’;
- ‘using the internet’;

### *Curriculum related uses*

- ‘research of different mammals’;
- ‘the skilful scientific activities which improves pupils’ minds and fulfil their artistic and cultural inclination such as artistic activities’;
- ‘story writing’;
- ‘poetry writing’.

### **Developing personal and professional identity**

*‘I am now constantly finding things that extend my knowledge as a teacher – making me really grow professionally. There is change. In the past, for example, we did planning, but we have to come think differently now, learning is now challenging us and we are exploring more. This year we are going to do even better, as teachers we are really learning.’ (Teacher Interview)*

Analysis of project teachers’ concept maps on the subject of ‘Teaching and learning with ICT’ suggest that project teachers’ knowledge developed significantly during the lifetime of the project from procedural knowledge of ICT and its general application to teaching and learning, to knowledge of how ICT could be appropriated for a range of personal, professional and classroom practices. Teachers’ pre and post project concept maps (shown in Appendix 3) illustrate this shift in understanding. In pre-project maps teachers mostly named discrete technologies and linked these conceptually to what they knew they could do in a general sense: ‘*communication – learners can communicate with people far far away*’ (Appendix 3 a); ‘*information – world news – latest events – newspapers*’ (Appendix 3 b). In post project maps, by contrast, teachers introduced personal pronouns (‘*I*’ and ‘*we*’) and represented personal experiences and/or uses of ICT rather than ICT devices e.g. ‘*personal - confidence – own ICT competence*’; ‘*activities - classroom-based- acrostics – fables/ intsoni - endangered animals*’ (Appendix 4 b) ‘*it helps especially when I was doing environment animals at the zoo and those at home learners saw them and the lesson became real*’ (Appendix 4 a). Some teachers integrated personal use of the hand-held devices into concept maps; one, for example gave her map four equally weighted branches entitled: *Learning; Resources; Research; Jornada*. This fourth branch was annotated: ‘*I record, take photographs, write, read stories*’. During interviews personal appropriation/ ownership of the technology was a strong theme, ‘*I use it everywhere*’; ‘*the jornada is my companion*’.

The Toolkit was both constrained and extended the social, intellectual and cultural meanings that teachers and students brought to it. The affordances of lap- top or hand-helds were to a degree created by the purposes, activities, needs and imaginations of teachers and students, as much as what they were able to do was moulded, extended and transformed by the technology. The research team had seen lap top data/ history of use as a mode of data collection that would help to document electronic products and teacher and student ‘ICT outcomes’. What such data exemplified was a more subtle process of development. Where tools really were serving day-to-day practices, then user(s) and tool(s) literally shared a common ‘history’ germane to daily concerns and activity. A young teacher in the early stages of the project, clearly working with difficulty, tapping out simple sentences on multiple word-processed documents over several days, or abandoning a half finished powerpoint. A work colleague painstakingly creating a CV and job applications over a two month period. A

mourning sister, expressing grief through the composition of a simple, but moving and accomplished, poem. A school principal creating, with some self importance, headed notepaper for the local Woolgrower's Association in order to apply to the District Council for a sheep shearing shed. Data (lesson plans/ lesson outcomes) evidenced teachers and students working in parallel on related activities, with increasing competence As device and user(s)' everyday histories developed together over time, so the digital Toolkit became integral to the classroom's day to day ' activity, part of its participants' thinking as usual'. Appendix 2 shows the nature and forms of professional activity that were cultivated by teachers and their pupils. Once such a point was reached, the research indicated, there was potential for significant classroom change. At this point the Toolkit became embedded into teachers' *personal* and *professional* knowledge, integral to their identities and practices: *'I have changed. It has made me proud because I know how to use ICT. At first I didn't know anything... it has changed us really.'* *'I am proud of myself really... the people as well- always congratulating us. The [project] teachers are good now, I think everyone is longing to study'*. A shift between the personal '*I*' and '*we*'/'*us*'/'*everyone*' indicated the way use of the Toolkit helped teachers construct - at one and the same time: a secure sense of personal identity but also a new belonging and sense of a wider collectivity. One DEEP teacher told us of her pride as she used her hand held device to do some professional reading in the taxi on her long daily journey to school, "How wonderful!" she commented, " it's now I can feel myself as a professional".

## IMPLICATIONS FOR POLICY

The study raises key issues for policy makers and educational planners. The research suggests that politicians and education planners need to:

- acknowledge the potentially key role of ICT for increasing access and improving quality learning
- ensure teacher development is not isolated from other ICT development such as those focusing on students and curriculum
- recognize that ICT policy and practice must be closely matched to local context and needs with a particular focus on classroom relevance and learner achievement
- understand that existing cost analyses are likely to be based upon outmoded ICT models and use.

In addition:

- recognize that personal or extended ICT use, together with peer and team learning, is what enables confidence and the integration of ICT into daily classroom and community practices
- understand the importance of user evaluations of both ICT hardware and software
- realise that the locally relevant content is important and should also be produced in local languages (such as isiXhosa)
- encourage the development of local and international professional e-networks so that school communities can share experiences
- build links between teacher education and agriculture, healthcare and other government services in their uses of and policies on ICT.

The use of professional ICT Toolkits, incorporating high quality resources and purposeful professional activities, can have a significant impact on the confidence, self-esteem and professional knowledge of teachers in some of the poorest parts of the world. They have the potential to raise the quality of school experience for teachers and students alike. In this way, ICT offers new possibilities to redefine and enhance the status of teachers within communities and more broadly across the communities they work with.

As a result of this study, the DEEP research team has re-conceptualised these new tools for learning, calling them **4D Technologies**. Digital technologies for teacher development, we suggest, need to be further researched to support processes and outcomes that are:

- **Developmental:** in a personal, school, community and global sense;  
and
- **Democratic:** enabling access, wider opportunity, giving a voice to the world's poorest;

They should be orientated towards:

- **Deep learning:** for teachers and their pupils; •  
and confer
- **Dignity:** raising the confidence and self-esteem of pupils, schools and their communities - and above all teachers.

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## APPENDICES

### Appendix 1 DEEP teachers' prior access to and uses of tools and artefacts (including ICT) for personal and professional development and practices

Teaching Toolkit	Teacher Development Uses (including curriculum & pedagogic purposes)	Types of teacher knowledge served	Comparative strengths	Limitations and requirements
<b>Chalk and chalkboard</b>	<b>Curriculum and pedagogic uses</b> <ul style="list-style-type: none"> <li>▪ Information giving/ taking</li> <li>▪ Teacher or student whole class activity (e.g. brainstorming)</li> <li>▪ Summary of concepts</li> <li>▪ Individual/ group or pair activities (including question and answer/ comprehension/ problems)</li> </ul>	Pedagogic Subject	Permanent resource; no complex set up or skills required Highly visible to all pupils Cheap and easy to use	Without careful planning encourages didactic teaching and rote learning Can be time consuming to write on-teacher needs to be in classroom in advance of class to prepare Handwriting legibility demanded of users Material ephemeral- cannot be stored and reused; material has to be erased for re-use Chalk needs to be kept safe- easily mislaid
<b>Class library</b>	<b>Curriculum and pedagogic uses</b> Can be used to develop pupils' <ul style="list-style-type: none"> <li>▪ Subject knowledge</li> <li>▪ Literacy skills</li> <li>▪ Information and scientific literacy</li> <li>▪ Stimulus for literacy activities such as: story telling and writing</li> <li>▪ Basis for comprehension activities</li> </ul>	Pedagogic Subject	Flexible use within classroom or at home. Requires no complex set up or knowledge. Can support individual and pair activity (less easy to use in groups)	Limited knowledge available from a small library. Books easily date Quality books are costly, cheap books wear out easily, become dog eared, torn, damaged.
<b>Note books/ pencils /pens</b>	<b>Professional uses (teachers)</b>	Pedagogic		Inflexible/ limited affordances



<p><b>Paper based curriculum documents &amp; teacher study materials</b></p> <p><b>Television</b> (home access only by teachers) &amp; <b>Radio</b> (home access only by teachers)</p>	<ul style="list-style-type: none"> <li>Note making</li> <li>Planning pupil activities</li> </ul> <p><b>Curriculum and pedagogic uses (pupils)</b></p> <ul style="list-style-type: none"> <li>Note making</li> <li>Literacy/ scientific/ information activities</li> <li>Field work</li> </ul> <p><b>Professional study</b></p> <ul style="list-style-type: none"> <li>course materials study</li> <li>subject knowledge updating</li> <li>studying examples of practice, use of classroom resources</li> <li>obtaining reference information</li> <li>carrying out independent research</li> </ul> <p><b>Professional study</b> Current affairs/ news updating Subject knowledge programmes</p> <p><b>Curriculum and pedagogic</b> Use of knowledge for classroom activities</p>	<p>Subject</p> <p>Pedagogic School</p> <p>Personal School Subject</p> <p>Personal Subject</p> <p>Pedagogic</p>	<p>Can be shared; can easily be taken home, stored, material erased. Wholly dependent on 'input'</p> <p>Lightweight; anytime anywhere use; can easily be taken home, stored, material erased. Wholly dependent on 'input'</p> <p>Lightweight; anytime anywhere use; can easily be taken home, stored</p> <p>Up to the minute information Radio and TV can in theory provide quality exemplars of new pedagogic practices &amp; introduce a range of new pedagogies and classroom activities.</p>	<p>(compare varied functionality of word processing &amp; of computer aided devices as set out in Table 2)</p> <p>Quality books are costly. Up to date material difficult to access Most professional books do not incorporate subject knowledge updating Easily worn with frequent use.</p> <p>Information can't be used in classroom except by reportage; Quality of educational material in practice variable and is 'wholly one-way' input.</p>	
	<p><b>Mobile Phones</b> including: contacts SMS<sup>1</sup></p>	<p><b>Personal and Professional Communication,</b> via SMS messages &amp; voice calls</p>	<p>Personal School</p>	<p>Voice calls allow for in depth, immediate and personal/ professional communication.</p>	<p>Voice calls can be expensive, especially internationally.</p> <p>SMS is limited to a small number of</p>

<sup>1</sup> In South Africa, the mobile phone is ubiquitous, mainly due to the large geographical scale, and land-line infrastructure. This means it is a technology all teachers are familiar with, and most have access to., if not personally, via a friend or colleague. SMS messages provide a low-cost, easy access, national and international communication. In these contexts, SMS seems to be served by a robust infrastructure

				characters (160)

**Appendix 2 DEEP teachers uses of ‘ICT Toolkit’ (Note – italics indicate unexpected findings)**

Project ICT Toolkit	Teacher Development Uses (including curriculum & pedagogic purposes)	Types of teacher knowledge to be developed	Strengths of digital devices	Limitations and requirements
<ul style="list-style-type: none"> <li>▪ <b>Laptop<sup>2</sup></b></li> <li>▪ Word processor</li> <li>▪ Spreadsheet</li> <li>▪ Presentation software</li> <li>▪ Email</li> <li>▪ Web browser (including audio, video and animation viewing)</li> <li>▪ Image viewer</li> <li>▪ Audio player</li> <li>▪ Games</li> <li>▪ ‘Beaming’ (infrared document transfer)</li> <li>▪ Docking station for handhelds</li> </ul>	<p><b>Personal activity</b></p> <ul style="list-style-type: none"> <li>▪ developing ICT skills</li> <li>▪ communication</li> <li>▪ <i>formal CV’s, job applications</i></li> <li>▪ <i>pursuing personal interests e.g. study</i></li> <li>▪ <i>supporting own children’s learning</i></li> </ul> <p><b>Professional study</b></p> <ul style="list-style-type: none"> <li>▪ course materials study</li> <li>▪ subject knowledge updating</li> <li>▪ studying examples of practice</li> <li>▪ use and creation of planning tools</li> <li>▪ using &amp; making classroom resources</li> <li>▪ obtaining reference information</li> <li>▪ carrying out independent research</li> </ul> <p><b>Professional Communication</b></p> <ul style="list-style-type: none"> <li>▪ collaborative working (partners from the same school working together at the computer)</li> <li>▪ collaborative working (with peers at other schools, with the project team)</li> <li>▪ document sharing / development</li> <li>▪ displaying work (teachers and pupils) to parents, teachers and governors.</li> </ul> <p><b>Classroom uses</b></p> <ul style="list-style-type: none"> <li>▪ learning resource</li> <li>▪ reference library (e.g. <i>thesaurus / dictionary/ encyclopaedia</i>)</li> </ul> <p><b>Curriculum/ Pedagogic activity</b></p>	<p>Personal</p> <p>School</p> <p>Subject</p> <p>Pedagogic</p>	<p>Flexibility - serves a range of personal, professional &amp; pedagogic purposes</p> <p>Range of uses - can be extended and adapted by additional software or hardware</p> <p>Mobility – enabling use in classroom / home / teacher workshops / church / hospital etc.</p> <p>Ownership- different user accounts enables a number of users to have a sense of ownership &amp; personalisation, as well as fostering collaboration.</p> <p>Information storage system -stores, organizes and archives data &amp; artefacts</p> <p>Operates without external electricity supply (albeit for a short time).</p> <p><i>Can integrate seamlessly into a classroom setting (at teacher or pupils’ desks), /be moved around as</i></p>	<p>Short battery life</p> <p>Expensive</p> <p>Needs care and protection from impact, water, dust, extreme temperature and humidity</p> <p>Screen size rarely suitable for whole class teaching with use of external monitor or projector</p> <p>Small speakers: sound inaudible except for small groups or quiet environments</p> <p>The promise of connected internet dependent upon external infrastructure, ongoing costs associated</p> <p>Although relatively mobile there are ongoing costs associated with powering the laptop.</p>

<sup>2</sup> In the project, laptops were made available only to teachers in South Africa, via corporate sponsorship

- composing texts and multi-media
- presentation to authentic audiences
- transforming texts
- information literacy
- scientific literacy
- knowledge of language (e.g. spelling / grammar / meaning / genre)
- open-ended investigations
- *bi-lingual reading and writing (e.g. Bible texts in Xhosa and English; bi-lingual online dictionaries)*
- collaborative learning
- problem solving
- peer tutoring
- communication skills
- photographic work
- *developing cultural understanding of world beyond local environment through access to and engagement with: images, information, people and institutions beyond the local context*
- presentation skills

**Intellectual tool generally for the development of:**

- critical thinking
- information handling
- higher level conceptualization
- problem solving
- collaborative tasks
- joint decision making and reflection
- complex group interaction
- research

***School & community related activities***

- *School and school principal administration (e.g. minutes of meetings, letters, policy documents, test papers, time-tables, school events, assessment records).*
- *adult literacy/activity*
- *CV's and job applications*
- *Community announcements*

*required.*

*Enables curriculum activity, not ICT, to be the visible focus of classroom. This may remain true even if there are several machines available for use in the classroom.*

*Small size, and free-positioning, mean the computer need not interrupt lines of sight in the classroom, between learners and teachers.*

*Can equally well support individual, pair or group collaborative work.*

**With addition of data projector, can be used with large groups of teachers in a teacher workshop.**

*When technical support is required, machines relatively easy to transport to and from schools / support centres.*

*The power consumption of a laptop (around 40W) is up to ten times less than that of a desktop (200-400W)*

	<ul style="list-style-type: none"> <li>▪ <i>community projects</i></li> <li>▪ <i>entrepreneurial development</i></li> <li>▪ <i>correspondence with official bodies (telecoms, local authorities, grant applications, bills, letters of complaint, service providers, etc.).</i></li> </ul>			
<b>Desktop<sup>3</sup></b>	As for laptop	As for laptops	<p>Since permanently 'situated' at a particular location, desktop less likely to be damaged 'in transit' than a laptop.</p> <p>Cables and peripherals may be permanently connected, saving time in 'setting up' for use.</p> <p>May be more robust in design and construction, than laptops.</p> <p>May have larger displays than comparably priced laptops, making them more suitable for some forms of group-work or whole class teaching</p> <p><i>Features in common with laptops:</i> Serves range of curriculum and pedagogic Purposes</p> <p>Range of uses can be extended and adapted by additional software or hardware</p> <p>Stores, organizes and archives information and artefacts</p>	<p>Requires permanent external electricity supply</p> <p>Large and fixed physical footprint can obstruct lines of sight between teachers and pupils</p> <p><i>Classroom organisation may be ordered around location of equipment, not the curriculum activity; even more so when desktop computers are being used. See a classroom with ten desktop computers in it, or a computer suite.</i></p> <p><i>Desktop computers do not lend themselves to use beyond the classroom, e.g. on location or fieldwork.</i></p> <p><i>Desktop computers cannot support the teacher in a range of non-classroom contexts: study; teacher workshops</i></p> <p><i>When technical support is required, it may be difficult to transport, especially in contexts where teachers do not have cars. This is particularly true of schools situated on unmain roads.</i></p>

<sup>3</sup> In the project, desktops were available to Egyptian teachers, as part of the standard ministry specification for media labs.

case) classrooms are not secure, there are enormous significant financial costs in securing the room (the costs in time to move the computer to and from the strongroom (or local home) each time u

*Moving desktop computers this way involves a high risk of damage to machines or people) and a demanding set-up / take d*

*The power consumption of desktop machines is typically five times that of a laptop.*

<p><b>Handheld</b></p> <ul style="list-style-type: none"> <li>▪ word processor</li> <li>▪ spreadsheet</li> <li>▪ web browser (including audio, video and animation viewing)</li> <li>▪ camera and image viewer</li> <li>▪ audio recorder / player</li> <li>▪ games</li> <li>▪ diary</li> <li>▪ contacts</li> <li>▪ 'beaming' (infrared document transfer)</li> <li>▪ docking station for handhelds</li> </ul>	<p>Many similar functions to desktop/ laptop computers as above. In addition support anywhere – any time learning (e.g. on buses). Additional functions:</p> <p><b>Personal &amp; Professional Development:</b></p> <ul style="list-style-type: none"> <li>▪ Readily accessible learning resources</li> <li>▪ E-books enable personal learning, study, planning and information- material can be bookmarked, highlighted, annotated and text extracted.</li> </ul> <p><b>Classroom Use:</b></p> <ul style="list-style-type: none"> <li>▪ Use of the stylus input is resonant of a notepad and pen, extends the learners knowledge of note taking from the familiar paper / chalkboard, to the handheld electronic notepad.</li> </ul> <p><b>Curriculum and pedagogic use</b></p> <ul style="list-style-type: none"> <li>▪ Mini-multi-media showcase, (e.g. reading kinetic poetry; hearing Martin Luther King speech; listening to animated fables, watching videos of effective classroom practice (e.g. peer tutoring).</li> <li>▪ photography</li> <li>▪ voice recorder (for language work and recording information &amp; events e.g. Mark Shuttleworth visit).</li> <li>▪ support for field work / school trips</li> <li>▪ facilitates collaborative work, both for groups of pupils and of teachers – device small, easy to pass around.</li> <li>▪ collaborative work encouraged by quick and simple facility of 'beaming' electronic notes and other artefacts.</li> </ul>	<p>Mainly personal and pedagogic, but research findings indicate strong potential for subject and school knowledge.</p>	<p>Ultra-mobility</p> <p>'Anywhere – anytime' learning</p> <p><i>Flexibility - serves range of curriculum and pedagogic purposes</i></p> <p><i>'Personal' computing – constant access and a sense of ownership, gives teachers liberty to 'play' &amp; explore "...it is my companion."</i></p> <p><i>sense of 'personal ownership' encourages teachers taking care of device.</i></p> <p><i>Runs for several hours continuous use (often equating to several days / up to a weeks use)</i></p> <p><i>remarkably robust in the challenging contexts of this study.</i></p> <p><i>teachers feel safe and secure carrying these 'invisible' devices, compared to conspicuous and attractive laptops.</i></p>	<p><i>Requires regular (daily / depending upon use) recharging.</i></p> <p><i>Prone to total data and application loss upon battery failure. ****<sup>4</sup></i></p> <p><i>Synching with main computer be prone to failure. ****</i></p> <p><i>Small screen size requires use of educational content designed primarily for larger computers.</i></p> <p><i>Limited storage capacity (media)****, although use of increasingly inexpensive capacity) memory cards may overcome this.</i></p>
<p><b>Mini-cameras</b></p>	<ul style="list-style-type: none"> <li>▪ creating &amp; recording resources for</li> </ul>	<p>Pedagogic</p>	<p>very small form - can easily be kept</p>	<p>low resolution images</p>

4

\*\*\*\*with the particular handhelds used in the study

	<p>classroom</p> <ul style="list-style-type: none"> <li>▪ <i>classroom literacy activities</i></li> <li>▪ <i>documenting pupil progress</i></li> <li>▪ <i>objectifying experiences (teacher and pupils) to help critical reflection</i></li> <li>▪ <i>scientific and social sciences project work and field work.</i></li> <li>▪ <i>facilitates displays, presentations, and teacher and pupil portfolios</i></li> <li>▪ <i>displaying school work to teacher / pupil peers, principals, governors and inspectors). Important in involving parents in settings where adult illiteracy is high</i></li> <li>▪ <i>personal photography (family/friends etc)</i></li> </ul>	<p>Personal</p>	<p>ready for use</p> <p>easily shared (taking &amp; viewing)</p> <p><i>ideal for fieldwork</i></p> <p>doesn't require separate batteries or charging</p> <p>"invisible" and secure</p> <p>no costs in film development</p> <p>instant &amp; share-able images, readily integrated into other documents</p> <p>minimal ongoing costs</p>	<p><i>shutter delay can mean you miss capturing the intended moment</i></p> <p>no flash</p> <p>relatively low quality images</p>
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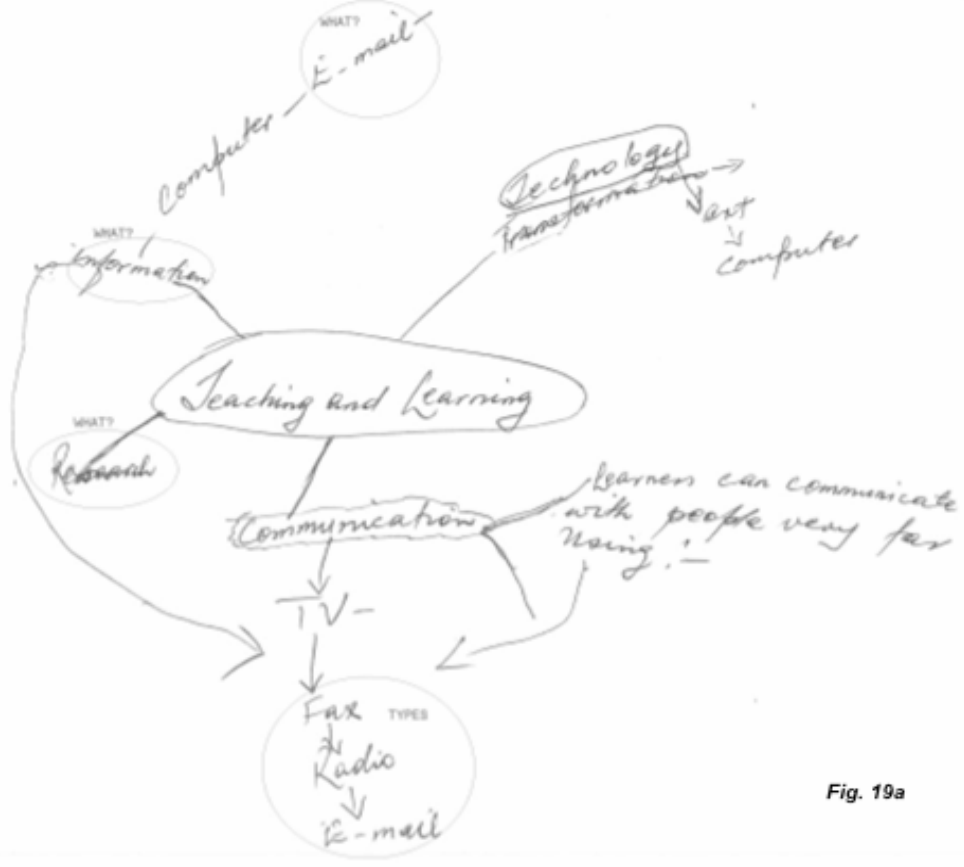


Fig. 19a



Fig. 19b

Appendix 3 a and b



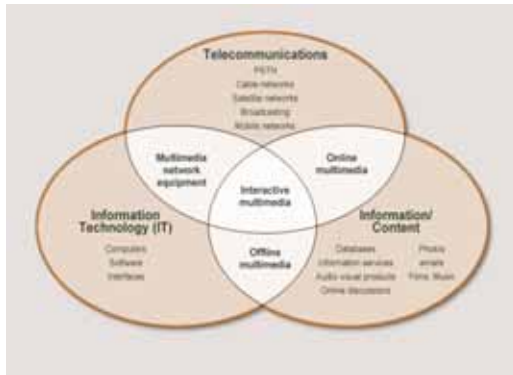
Fig. 19c



Fig. 19d

Appendix 4 c and d

iii We use the term "Information and Communications Technology" (ICT) to encompass a full range of technologies - from traditional, widely used devices such as radios, telephone or TV, to more sophisticated tools like computers or the Internet. (Weigel, 2004, p.19) based on the OECD definition.



This definition emphasises the intersection of information technology, information content and tele-communications in enabling new forms of knowledge production and interactivity. Such a definition encourages a broader conception of ICT and assigns equal status to traditional communication technologies (e.g. radio and TV) and newer digital devices (such as cell phones, handheld computer) and associated activities (e.g. the use and production of moving images, music making, text messaging, photography and mobile computing).

ii Emphahandleni means 'in the rural areas' in isiXhosa, one of the major home languages of the region.

iii i.e. the combined measure of numbers in poverty and their depth below the poverty line

iv The comparative provincial data is: Gauteng 4%, Northern Province 16.5% Kwa Zulu Natal 19.9%; Western Cape 3.4% Northern Cape 1.9% Free State 9.9%, Eastern Cape 24.9%.

v Inkanyezi sisinambuzane esincinane, esikholisa ukuqapheleka ebusuku ngenxa yokudanya-danyaza kwaso. Udanya-cimi esiye simenze uthi "Ndileq' undibambe!".

Kokukhanya okuye kubenomtsalane ebantwaneni. Ayibungakanani bayo obubalulekileyo, koko ligalelo layo ekukhanyiseni nakwintunguzi yobusuku. Umntu ongaziyo kuye kuthiwe usebumnyameni. Nantsi inkanyezi engu-DEEP isiza nolwazi lwe Computer ebantwaneni. Masiyileqe siyibambe ingekathi "swaka!" [A glowworm is a small insect that is noticeable at night by flashing. It is the flashing that makes it attractive especially to children. Somehow you are drawn to chase and catch it because you want to capture the glow. It is not its size that is important, but it's impact in illuminating even the darkest nights. In Xhosa culture, a person lacking in knowledge is said to be in the darkness. This glow worm (DEEP), is enhancing the use of computers in learning to children. Let us catch it before it disappears. Adi Kwelemtini, Project Co Coordinator, South Africa]

vi It was also implemented in 12 school in Egypt. It is planned to develop new pilot project in other contexts; in Eastern Cape the project will be upscaled. Additional research is being carried out specifically on hand held use (see [www.bridges.org/competitionwinners](http://www.bridges.org/competitionwinners)) and the use of video conferencing (see [www.open.ac.uk/deep/deepa](http://www.open.ac.uk/deep/deepa))

vii During the project's scoping phase the DEEP team had observed with keen interest the widespread use of mobile phones in the rural areas of the Eastern Cape – and how important this mode of technology is to those living in isolated settings. Some teachers reported they walked many miles each week to the nearest source of electricity in order to charge these devices.