Do new information and communications technologies have a role to play in achieving quality professional development for teachers in the global south?

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Introduction

‘Globalisation must [...] mean justice on a global scale’.

(Commission for Africa, 2005, p.22)

Underpinning this paper is the view that Africa must drive its own development, but that educators world-wide need to support this process if quality teaching and learning is to be achieved for all. It is addressed to the international community of educators and educational policy makers, who, it is argued, need to commit to joint action and creative research in respect of the challenge of Education for All.

The first section of the paper, A Global Challenge for Teacher Development, sets out:

- the implications for teacher professional development of the Education For All (EFA) agenda;
- the potential of new information and communication technologies (ICT) in helping to address this problem;
- an overview of the Digital Education Enhancement Project (DEEP), an applied research project, which is exploring new forms of professional development using ICT – for teachers in remote and resource challenged environments;
- a model of teacher professional knowledge (Banks, Moon and Leach, 1999; see also pages xxx of this journal), which is used to frame and conceptualize teacher development within the DEEP programme.

In the second section, Towards New Models of Professional Development, four categories of teacher professional knowledge from this model are used to interpret and explore the findings of the DEEP programme and its impact in teacher knowledge and development:

- subject,
- school,
- pedagogic
  and
- personal.

The paper concludes that information and communication technologies can no longer be viewed as some sort of optional pedagogic strategy available in ever increasing sophistication, as well as quantity, to only a small proportion of the world’s teachers. Information and communication technologies need to be seen as an essential aspect of teaching’s cultural toolkit in the 21st century, affording new and transformative models of development that extend the nature and reach of teacher learning wherever it takes place. Such models must be experienced, shared and evaluated by educators world wide if the global commitment to achievement of the EFA targets is to become a reality.
A Global Challenge for Teacher Development

‘What struck me so forcefully was how small the world had become during my decades in prison. [ICT] had shrunk the world, and had in the process become a great force for eradicating ignorance and promoting democracy’.
(Nelson Mandela, Long Walk to Freedom)

Over 100 million children worldwide go without primary schooling. Running parallel with this momentous problem is a growing imbalance between the output of trained teachers, specifically in low-income countries, and the demand as primary provision is necessarily expanded. A third of existing teachers in sub-Saharan Africa, for example, are untrained. Of the thousands recruited each year, they largely have inadequate subject knowledge and little if any pedagogic preparation.

The challenge of providing universal primary education is, in almost all respects, greatest in Sub-Saharan Africa. Four out of every ten primary-age children in the continent do not go to school (UNESCO, 2002). Added to this the poor quality of much schooling means children leaving school with inadequate skills, and results in repetition and completion rates such that a World Bank evaluation has shown many countries must devote as much as 50 per cent more resources than others to produce a primary school graduate (World Bank, 2000).

Nearly ten years ago, UNESCO forecast that Africa must expand its teaching force at a rate of 5.6 per cent per annum during the 1990s if it was to cope with this challenge. It has not managed to achieve anything like this rate. Over the last fifteen years the teaching force in Africa has grown at only 3.4 per cent, slightly ahead of the growth in the number of children in school, but at nothing like the rate needed to provide enough teachers (Perraton, 2000). Teacher supply in Africa also has to reckon with the consequences of the HIV/AIDS since teachers are not exempted from the pandemic. UNICEF estimates that 860,000 children in sub-Saharan Africa lost their teachers to AIDS in 1999 (UNESCO, ibid).

In addition, in many countries, quite apart from the difficulties of training enough new teachers, the existing teaching force is also under-qualified, whether in academic or professional terms, or both. And if pre-service training is a neglected area, in-service training is commonly even more under-developed. Although there is wide recognition that teacher education, training and professional development need to be integrated in ways that operationalise lifelong learning for teachers, the resources allocated to it are usually inadequate and the opportunities few.

Not only is it a major undertaking for many countries to train enough teachers, but also to develop their academic knowledge and professional skills to the level required to ensure effective primary education. This training challenge also needs to be seen in the context of additional concerns about the quality and relevance of current teacher education systems in many countries - and hence of the quality of classroom practice. A recent study by Dembélé and Miaro-II (2003) indicates that unhelpful teaching practices and rigid, chalk-and-talk, teacher-centered/dominated pedagogy remain the norm in Sub-Saharan Africa. ‘Such pedagogy places students in a passive role, limits
their activity in class to memorizing facts and reciting them back to the teacher’ and is also ‘reflected in classroom assessment practices (p.6).’

It is clear that existing institutions of teacher education created for the twentieth century will be unable to cope with the scale and urgency of demand in the twenty-first (Moon, 2000). The resources just do not exist to take millions of teachers away from their classes. In any case much recent research indicates that locally based training, properly resourced and supported, can be a highly effective form of professional development (e.g. Zhao & Frank, 2003). Provision of teacher education in Sub Saharan Africa, this paper argues, will in the future need to be more flexible, allowing teachers to acquire (individually and with others) the knowledge and skills that will develop their own professional learning.

Is there a role for new information and communication technologies in this process?

Some experts have begun to argue that in order to respond to these needs at the scale required, teacher education in the less developed countries could exploit new forms of information and communication technologies (ICT) (e.g.Cawthera, 2001; Dhanarajan, 2001; Marker et al, 2002). Whilst the advent of ICT over the last decade has opened the door to a flurry of rhetoric, there has also been some thoughtful and sustained argumentation about its potential use in the countries of the global South. A strategy paper published by DFID, for example, concluded that ‘properly deployed, ICTs have enormous potential as tools to increase information flows and empower poor people’ (Marker et al., 2002, pp. 4-5). It recommended that governments should ‘mainstream attention to the information and communication aspects of poverty and appropriate uses of ICTs in the development process’. This process should include ‘providing concise, evidence-based material drawing on research and experience about what works and what does not’ (p.5). Raj Dhanarajan, formerly President of the Commonwealth of Learning, specifically addressing the educational potential of ICT, suggested that, ‘If applied with thought, extreme sensitivity and knowledge..... (ICTs) afford the means to extend access to education and training to the knowledge-poor, the unreached, the isolated and those who have been ignored for too long’ (Dhanarajan, ibid, p. 134). Dladla and Moon (2002) speaking from a north/south partnership have strongly argued: ‘Emergent models of development that exploit new forms of technology need to be examined in order that new practices of teacher education might be shared, experienced and evaluated globally’ (p.2). A study of computer costs in schools in less developed countries, also carried out for DFID by Cawthera (2001) pragmatically concluded that in contexts such as sub-Saharan Africa, where there is simply not the capacity to train and retrain the huge numbers of teachers currently required, ‘school-based, computer supported teacher training might be part of the solution to this problem. Technology could make teacher training experiences better and shorter’ (p.10).

Despite the growing recognition of the potential role of ICT in teacher education within Africa however, most of the published literature available internationally reports on research and practice primarily based in industrialised, relatively resource-rich contexts. Where explorations of the potential of technologies are made for teacher development in the African context, a transmissive view of teaching and learning often underpins the analysis (Leach, 2005, forthcoming), with ICT assigned equal status with other ‘instructional media’ i.e. print, radio, TV, CD-ROM. Members of the Research Group on International Development in Teacher Education across
Cultures and Societies (RITES) based at the Open University (UK), have been exploring a variety of models of teacher education for over a decade e.g. Moon 2000; Leach, 2002, Dladla and Moon, 2002, Leach, Moon and Power, 2002. They have argued that ICT can offer teachers, whatever their context:

- **scaffolding tools** to support their own construction and understanding of new academic and professional knowledge;
- **environments and contexts for learning**, enabling teachers to experience new situations, activities, problems and solutions, practices and people;
- **communicative tools**, facilitating unique social participation structures between teachers and other educators;
- **meta-cognitive tools, enabling teachers to reflect on the learning process** itself, both at individual and group level (Leach et al. ibid.).

The Digital Education Enhancement Programme (DEEP) represents one of the more recent outcomes of this exploratory work (Leach, 2005). It is also one of the very first examples (at the time of writing perhaps the only example) of a planned investigation into how mobile technologies can be used to support teacher professional development in the challenging circumstances of sub-Saharan and North Africa (Leach et al, 2004).

The Digital Education Enhancement Project

In poor communities the scarcity of trained local personnel (teachers, health workers, agricultural extension workers) and the impediments they face in accessing vital information and enhancing their skills, perpetuates the low educational attainment... of these communities... ‘ (Marker et al., 2002, p. 7)

**Project overview**

The Digital Education Enhancement Project is an applied research project, focusing upon two research questions:

- How does 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?

The project’s aim is to contribute to the growing, but as yet relatively small number, of in-depth research studies that can be used to inform policy makers, educational researchers and others interested in ways in which new forms of technology can enhance teachers’ capabilities and improve knowledge and professionalism in the global South.

The first phase of the DEEP project was implemented in 12 primary schools in Egypt and 12 in South Africa, with 48 teachers (two per school) and over 2000 pupils. Between January 2002 and March 2003 participating teachers carried out and evaluated a sequence of curriculum focused, school based professional development activities using a range of new technologies, including hand held computers (Leach 2003; Leach, Klaas, Mnqgibisa, Power, 2002). The majority of participants were new to the use of ICT. The intervention and associated research was funded by the
Department for International Development (DFID) and coordinated by the Open University (UK), with the University of Fort Hare (Eastern Cape, South Africa) and the Programme, Planning and Monitoring Unit (Egypt) (Leach 2005 forthcoming).

Research design
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. Social practice theory (see Chaiklin and Lave, 1993) provided a strong underpinning not only to the conceptual framework of the research design, but also to the nature of the ICT intervention. 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, 2005, 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. Lave and Wenger, 1991).
- **Second:** *Teacher learning is always a situated and active experience* - people are in essence agentive (Sen, 1999), proactive, intentionally focused (Bruner, 1996) on the purposes of the communities to which they belong
- **Third:** *(most importantly for this project)* *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)
- **Fourth:** *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

One of the strengths of a socially situated view of learning, as these principles indicate, is its ability to encompass a variety of settings. The concept of ‘community’ (Leach, 2001) becomes increasingly important as the communications aspect of ICT develops, in particular as the national and international developments outlined in our introduction begin have a direct impact on the classroom.

As the project unfolded, it became clear that tools and artifacts are fundamental to any human activity, including teaching and learning to teach (e.g. Vygostky, 1962; Wertsch, 1995). From this perspective teacher development is distributed, or ‘stretched over’ the individual, other educators, learners (and many others), activities, tools and artefacts of the setting (Lave, 1988; Putnam and Borko, 2000). Indeed we often enter into a kind of intellectual partnership with the tools that we daily take for granted in our different learning communities. Technologies, combined with what Bruner calls the ‘soft tool’ of language (e.g. shared symbols, special vocabularies,
notational systems and the like), offer a range of affordances for making people smart (Norman, 1988), though none of them guarantee it. Whether it be high tech whiteboards and libraries; test tubes and bunsen burners; canvas and oils; footballs and hurdles; or simply the use of rudimentary chalk and chalkboards and a meager ‘book box’ (commonplace within the primary schools selected for the DEEP study), human tools and artefacts define both the reach and the limitations of knowledge and activity (Leach, 2005 forthcoming) - including the professional practice of being a teacher. Culture provides the ‘toolkit’ of technologies, techniques and procedures with which different groups and teaching communities learn about, respond to, act on and manage their experience of the world (Bruner, 1996).

An existing model of teacher professional knowledge (see for example Leach and Banks, 1996; Banks, Leach and Moon, 1999; Leach and Moon, 2000; McCormick and Scrimshaw, 2001) has been used within the DEEP research design as a means to understand and analyse changes in teachers’ thinking and practices during the project.

Fig 1 A model of teacher professional knowledge (Banks, Moon and Leach, 1999)

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. This approach to teacher knowledge 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.

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.

In these remote locations, 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 recycled materials) 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.

Learning technologies within the project
As our four principles make clear, really useful technologies become embedded into the everyday practices, the ‘thinking as usual’ of communities (Leach, 2001). Indeed, research shows that the ways in which teachers use ICT within educational communities, has a far greater effect on learning than physical access. In conceptualizing the ICT that would be integral to the DEEP programme, the research team was guided by the new forms of activity and teacher knowledge - ‘subject’, ‘school’, pedagogic’ and ‘personal’ (Figure 1) it hoped might be appropriated by project teachers and their students within schools and classrooms.

The project takes a broad view of ICT, encompassing more traditional technologies such as radio and TV, already familiar to teachers, in line with the definition used by the ICT4D 2003 platform at the Geneva Summit (Weigel and Waldburger, 2004)’. No primacy is assigned to any particular technology; use of tools within the project is considered first and foremost with respect to their capacity to support two inter-related pedagogic purposes (1) the development of teachers’ professional knowledge and (2) the improvement of classroom practices. Whilst educational policy makers generally start with questions about hardware and software when considering ICT innovations (e.g. ‘How many computers / computer suites?’; ‘How many can we afford?’; ‘What infrastructures are needed?’) DEEP starts with a broad view of teacher knowledge and pupil learning and how ICT might help the development process. For example, in order to develop teachers’:

- subject knowledge, provision of resources detailed and broad enough to support professional enquiry is required (e.g. Internet access to a range of high quality, subject-focused multimedia resources related to the project’s content). Where internet access is fragile, or in some cases non-existent, CD (or DVD)
– ROMs can provide alternative, albeit more limited, access to quality information and data;

- **pedagogic knowledge**, requires a display large enough for several pupils or teachers to be able to see a computer screen at one time so they can 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 requires a mobile device allowing for portability and the opportunity for teachers to ‘tinker’ and ‘play’ with ICT, as well as to make mistakes in privatevi. Teachers need access to ICT across a wide variety of settings [e.g. at school, the local environment, teacher meetings and at home].

In this way, informed by the model of professional knowledge outlined in more detail in the article on pages xxxx of this journal, a minimum specification for a professional ICT toolkit was created. In the Eastern Cape where most communities (including schools) had negligible experience of new forms of ICT and certainly no access (with the exception of cell phones), a common professional ICT toolkit was provided to participating school and teacher pairsvii.

### ICT Professional Toolkit (for use by project pairs 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
- Access to project digital camcorder (shared by the 12 schools)
- Personal mobile phone (not provided by project).

**Professional development activity in the programme**

A cycle of Professional Activities, each one 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 2). 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.
Previous evaluations of programmes designed to introduce teachers to ICT for subject pedagogy (e.g. the UK NOF funded national training, 1999-2003) suggests that a generic approach - one that requires teachers to make their own curriculum linkages - can lead to over-concentration on IT skills. A locally relevant environmental theme, (Endangered Animals), was therefore chosen in order to model 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. A further resource was developed as a result of teacher feedback, some three months into the programme in the form of Activity cards 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.

DEEP also introduced teachers and students to a wide range of new teaching approaches (pedagogic knowledge), many unrelated to ICT: strategies for drama, field work, as well as approaches to peer tutoring, brainstorming, scaffolding and modeling. Emphasis was placed on ICT as being one pedagogy amongst many. The professional Activities were also progressively focused on developing teachers’ school knowledge (classroom organization, planning, teaching and assessing with ICT). Materials supporting the development of new subject knowledge (e.g. animal classification for science) were introduced as appropriate.

Initial Activities encouraged teachers to consider how a range of familiar technologies were already an inseparable part of their daily lives (e.g. bicycles, stoves, cell phones), enabling them to achieve things that would otherwise be difficult – or even impossible. They were then invited, as the DEEP programme progressed, to consider and evaluate for themselves how new forms of ICT might be used in their own
teaching practices, in their particular settings and with their own students. The development of professional knowledge remained the key determiner in how ICT was defined within the programme. No form of ICT was introduced within a professional Activity unless it could be shown to make the teaching and learning process more efficient in some way - or where it potentially extended or transformed the learning process (for teachers and/or students) (McCormick and Scrimshaw, 2001).

Project participants’ prior knowledge and experience
The majority of teachers in both countries 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. 14: 58% of the Eastern Cape teachers 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%).

Fig. 3 Prior use of technology, Eastern Cape

Appendix 1 summarizes the most commonly used technologies and artefacts that teachers and learners in the Eastern Cape used prior to the project: their strengths and weaknesses as well as their capacity for supporting the developing teachers’ subject, school and pedagogic knowledge. TV, Radio and cell phones have been included, since the majority of teachers had some access to these technologies at home- though neither TV nor radio were available in the majority (9) of the schools, nor in their immediate communities.

Teachers were outspoken about the limitations and restrictions of these resources, - especially as they became used to a more sophisticated professional toolkit. One project pair had used the traditional resources of Table 1 (especially the small school library donated by the USAID’s READ project) to develop a range of highly innovative pedagogies with their pupils prior to the project. Nevertheless they 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.

‘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’.

In the following section the DEEP study findings are explored using the categories of teacher knowledge (Figure 1) as a framework.

**Developing professional knowledge: study findings**

‘I could never go back to not using ICT... I feel in touch with the latest developments in education... It enables us to progress into the 21st century by leaps and bounds. They [students] need to be properly equipped to use ICT because of the age in which they are growing up’ (Eastern Cape teacher, end of project interview).

‘I love to use the computer, I use with no fear’ (Cairo teacher, end of project interview). ‘The [hand-held] is my companion’ (Eastern Cape teacher, end of project interview).

**Overview of findings**
Teacher participants in both contexts quickly learnt to use ICT for a range of personal, professional and pedagogic purposes and during the lifetime of the project teachers grew significantly in their confidence to use a variety of digital devices. The development of basic computer skills was largely unproblematic, largely because teachers were keen to gain mastery of new pedagogies and curriculum related benefits. Participants were observed using desktop/ laptop and hand-held computers and a variety of digital softwares and other peripherals (e.g. Word, Calculator, PowerPoint, Internet, E-mail, Games, Scanner, Printer, Photocopier, Camera) in a short time frame. By mid project (August- November 02) almost a third of teachers indicated, in interim questionnaires and interviews, that they had begun to feel ‘somewhat confident’ in the use of computers. Two thirds reported ‘medium’ to ‘high’ confidence. By project close all respondents reported ‘medium’ or ‘high’ confidence, and offered extensive additional commentary: “The project has removed my fear in using various communication and information resources”; “using computers gave me high confidence” etc. Teachers’ awareness that they were participants in a research project seemed to encourage experimentation and support reflectivity. The value and high status accorded to their ongoing evaluations of ICT enhanced professional development activity – together with the self-esteem such activity afforded project participants – provides important general lessons for similar CPD programmes.
No significant correlation was found between teachers’ prior use of new technologies and the ability to successfully develop ICT-enhanced classroom practices. In addition there was no necessary link between the ICT access and infrastructures of project schools/communities and successful teacher outcomes. Teacher participants with no previous experience of ICT and/or no prior experience of using ICT for teaching were observed to have developed sustained and effective classroom practices. The data also indicated that successful outcomes in terms of the development of teachers’ personal and classroom use of ICT were not dependent on either the size or nature of their school’s ICT provision, nor its infrastructure. Two rural schools became lead schools and displayed highly productive outcomes, despite having had no ICT resource prior to the programme. Neither school had phone lines and electricity in both contexts was fragile. Across the project overall the only two schools that had sizeable ICT computer suites were the least successful in achieving project outcomes.

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]

‘Hello, I used the camera when Mark Shuttleworth visited Butterworth. You know him, the first African to go into space. I also recorded his speech while making a lecture about his journey into space. How wonderful! ... its now that I can feel myself as a professional. Warm greetings. Bye (E-Mail from project teacher, 2002)

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 a way that is related to my speciality’ (Exit Questionnaires, 2003). 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.
Evidence from several recent studies (see the review of ICT and pedagogy by Cox et al., 2004 for example) suggests that when teachers use their knowledge of subject, their use of ICT has a more direct effect on student attainment. Project data confirms this, illustrating the way in which ICT served concurrently as a means of developing teachers’ subject knowledge, and as a pedagogic tool for enhancing students’ scientific and information literacy. Analysis of practice over time in remote, information poor environments suggests that use of ICT can raise the quality of teaching and learning in schools and communities that are starved of resources and information. In cost effectiveness terms it would appear that such schools derive a much greater incremental benefit from one functional computer than institutions already saturated with resources (Cawthera, ibid. p.30).

**Developing school knowledge**

“The poor have information, knowledge and communication needs, as do all people, yet they are often unable to address them ...... given the multiple constraints they face, the poor are either unable to meet their needs or must do so in costly ways that may perpetuate their disadvantaged position.” (Marker et al., 2002)

“I can’t go into a class now without having planned activities thoroughly”
(Teacher interview, South Africa, 2003)

“Now I come to feel creative”(Teacher interview, Cairo, 2003)

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 daily task of planning for teaching is arguably the most demanding and often most underrated professional task of all, involving teachers in a wide range of roles – for example as researchers, planners, project managers and resource providers. This study revealed just how exhausting and de-motivating it can be for teachers to maintain such intellectually demanding activity day after day with the minimum of resources and only rudimentary planning tools such as those outlined in Appendix 1. Prior to the project participants had no routine access to the professional artefacts and technologies that many teachers in the North take for granted (e.g. planning templates; up to date pedagogic ideas; photocopiers; reference materials, example lesson approaches; dictionaries; thesaurus; well-resourced libraries etc.). 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, 2003

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. 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.

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. Project pairs were encouraged to spend time initially becoming personally confident with the kind of tasks they might in the future get students to carry out in the classroom. Even then the researchers assumed practice would develop slowly – if at all – in those circumstances where teachers were struggling with large classes, limited ICT access and negligible ICT support. 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.

Figure 4 enumerates products gathered from lap-tops at mid project point, categorized according to the type of teacher knowledge (i.e. school/ subject/pedagogic/ personal) that seemed to the research team to be most dominant in their production. Whole school/community products are also indicated. In all but one project school the number of products associated with classroom teaching (pedagogic) were in the majority. Project teachers identified their own, most frequent, use of ICT within the classroom as:

• to facilitate collaborative working (74%);
• to present material (54%);
• to enable independent learning (31%).
Figure 4 Laptop data collected six months into the project (Eastern Cape)
Teacher reports on student use of ICT within the classroom were extremely varied. The majority of teachers in both countries (70% SA; 72% Egypt) 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, March 2003)

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, enumerated in Table 2 below. 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/ intsomi - 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 study shows how significantly ICT shapes the social and cultural meanings that teachers and students bring to it. The affordances of lap-top or hand-holds 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 are serving day-to-day practices, then user(s) and tool(s) quite literally share a common ‘history’ germane to daily concerns and activity. Lap - top data provided verification of this process of appropriation as described by participants. 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. Most frequently the data showed
teachers and students working on related activities, with increasing competence, on a
range of classroom activities (lesson plans/lesson outcomes). As device and
user(s)’ everyday histories developed together over time, so ICT became part of a
classroom’s day-to-day ‘thinking as usual’. Once such a point was reached, the research
indicates, there was potential for significant classroom change. At this point ICT use
became embedded into personal and professional knowledge, integral to user’s 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’. The shift between the personal ‘I’ and
‘we’/‘us’/’everyone indicated the way ICT use seemed to help 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.

Changing professional toolkit; changing practices

I have argued elsewhere (Leach, 2001) that creative communities always use new
technologies to push the boundaries of new knowledge and practices; teaching
communities are no exception. Where a teaching community finds authentic uses for new
technologies and related artefacts (perhaps because of new views of knowledge, a
demand for subject knowledge entitlement or even an understanding of the benefits of
ICT in developing school or pedagogic knowledge), such uses will become embedded
within that community as an essential aspect of the knowledge. In Appendix 1 the use of
tools and technologies made by participants prior to the DEEP project are set out.
Appendix 2 summarises the uses made of some of the newer digital technologies used in
the project (i.e. lap top, desk top and hand held computer; digital cameras) and the unique
development of subject, school and pedagogic knowledge they enable. It compares the
strengths and weaknesses of the different tools, as well as the wide variety of new
professional and classroom activities that the digital technologies facilitated, including a
new set of intellectual tools that significantly extended and transformed the nature and
quality of the learning process. Several types of classroom activity were quite unexpected
to the research team and these are indicated in italics in Appendix 2. For instance use of
the hand held voice recorder by students to support language development; classroom use
of the scanner to document local herbs and plant species; teacher use of the camera to
document student activity for display at parents’ meetings.

It might well be argued that in circumstances where teachers struggle without an
adequate professional toolkit to support school knowledge, education is destined to
remain an impoverished experience for teachers and students alike. Certainly there is
little evidence that basic education as currently practised in many parts of sub-Saharan
Africa is increasing access or quality (Cawthera, 2001). Teacher development stands as a
cornerstone for change, but professional work, as this study shows, demands complex
professional knowledge. Such knowledge I have proposed can be significantly enhanced
by the use of up to date, ICT professional toolkits such as those used by project teachers.
Management theory uses the phrase ‘helicopter ability’ to describe leaders’ capacities to
rise above the everyday, to look beyond the immediate and distinguish, as it were, the wood from the trees. We term the distancing effect that ICT-use had in the project ‘the Intambanane effect’ (intambanane is the Xhosa word for a ‘dancing kestrel’). For not only did professional use of ICT allow teachers to rise above minutiae and the daily undignified struggle to teach with minimal resources. Such practice also enabled them to dance, to dip and to dive. Many of the teachers began to think creatively with colleagues about how digital technologies might be appropriated to develop their school, subject and pedagogic knowledge - and in so doing, their own personal and professional horizons were significantly widened.

Conclusion
In most works concerning theories of teacher professional development, ICT is rarely considered. Where it is a focus, it is viewed either as an adjunct to - or as an additional, if optional pedagogic strategy - for teacher (and pupil) learning. Two informing principles of the DEEP project (see page 6) challenge this view, i.e. that

- community is an epistemological principle of teacher learning;

and that

- tools and artifacts are an integral (not optional) aspect of a communities knowledge and learning – and this includes teaching communities.

The study has also yielded a new principle:

- teacher learning is a cultural and historical process, both at the level of the individual and of their community of practice. This includes the uses made of tools and artefacts.

The use made of tools and artifacts by any teaching community, as the DEEP research vividly illustrates, depends and builds on the history, culture and traditions of existing practices. The uses made of tools and artifacts by individual teachers are in turn inextricably linked through their personal histories to broader social/school based practices and perspectives. Linear theories of teacher development tend to suggest that there is one, correct course or sequence of development, leading to a fixed end point of mature fulfillment, measurable in terms of specific competences. Perhaps this is one reason why sceptics try to suggest that teachers in resource challenged communities are ‘not yet ready’ for state of the art technologies. Yet individual and societal intellectual development is complex and never follows a linear course. Teacher development and change can only be understood by tracing innovations, changes and disruptions within the local culture- both historical and contemporary – in relation to collective as well as individual learning histories. Such complex developments can only be expanded by taking account of teachers’ past, as well as their current access to - and use of - technologies, tools and artifacts.

Change and transformation I have argued, is an inevitable outcome of the deep link between learning and communities. ‘Shared participation is the stage on which the old and the new, the known and the unknown, the established and the hopeful, act out their differences and discover their commonalities, manifest their fear of one another, and come to terms with their need for one another’. (Lave and Wenger, 1991, p.116).
Teaching communities are always in motion since change is a fundamental property of communities and their activities. Everyone can to some degree therefore be considered as
a ‘newcomer’ to the future of a changing community / professional practice. New
technologies I propose are at the heart of radical change.

This paper makes three propositions:

- the worldwide challenge of Education For All has a concomitant challenge to provide
  quality teacher education that will make the experience of schooling meaningful and
  productive;
- given this context, there is a need to research and evaluate new models of
  professional development, models which will exploit the potential of new forms of
  technology for the improvement of teachers’ subject, school, pedagogic and personal
  knowledge;
- teacher educators world-wide can contribute to a rigorous investigation and debate of
  new models and approaches, based on shared and considered evidence.

Across the world, many internationally recognised institutions and groups drive the
improvement of teacher education, attracting scholars, new research and ideas from every
part of the globe. Few of these are situated in the developing world. Few are driven by
the real agendas of the poor and the dispossessed. A task for teacher educators world
wide is to create a new and imaginative architecture for partnership, discourse and debate
that is truly international, that draws on wide ranging practices and scholarship, and
which embraces the challenge to further research some of the questions and issues raised
in this paper. The form of that architecture, the role of individuals and institutions in
creating and working together in this provides an agenda for the next stage of
development.
References


http://web.udg.es/tiec/default.asp (url last accessed 1.6.04)
### Appendix 1 DEEP teachers’ prior access to and uses of tools and artifacts (including ICT) for personal and professional development and practices

<table>
<thead>
<tr>
<th>Teaching Toolkit</th>
<th>Teacher Development Uses (including curriculum &amp; pedagogic purposes)</th>
<th>Types of teacher knowledge served</th>
<th>Comparative strengths</th>
<th>Limitations and requirements</th>
</tr>
</thead>
</table>
| Chalk and chalkboard     | Curriculum and pedagogic uses  
- Information giving/ taking  
- Teacher or student whole class activity (e.g. brainstorming)  
- Summary of concepts  
- Individual/ group or pair activities (including question and answer/ comprehension/ problems) | 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 |
| Class library             | Curriculum and pedagogic uses  
Can be used to develop pupils’  
- Subject knowledge  
- Literacy skills  
- Information and scientific literacy  
- Stimulus for literacy activities such as: story telling and writing  
- Basis for comprehension activities | 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. |
| Note books/ pencils /pens | Professional uses (teachers)  
- Note making  
- Planning pupil activities  
Curriculum and pedagogic uses (pupils)  
- Note making  
- Literacy/ scientific/ information activities  
- Field work | Pedagogic Subject  
Pedagogic School | Can be shared; can easily be taken home, stored, material erased. Wholly dependent on ‘input’ | Inflexible/ limited affordances (compare varied functionality of word processing & of computer aided devices as set out in Table 2) |
<table>
<thead>
<tr>
<th>Paper based curriculum documents &amp; teacher study materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Television</strong> (home access only by teachers) &amp; <strong>Radio</strong> (home access only by teachers)</td>
</tr>
<tr>
<td><strong>Professional study</strong></td>
</tr>
<tr>
<td>• course materials study</td>
</tr>
<tr>
<td>• subject knowledge updating</td>
</tr>
<tr>
<td>• studying examples of practice, use of classroom resources</td>
</tr>
<tr>
<td>• obtaining reference information</td>
</tr>
<tr>
<td>• carrying out independent research</td>
</tr>
<tr>
<td><strong>Personal study</strong></td>
</tr>
<tr>
<td><strong>Subject</strong></td>
</tr>
<tr>
<td><strong>School</strong></td>
</tr>
<tr>
<td><strong>Lightweight; anytime anywhere use; can easily be taken home, stored</strong></td>
</tr>
<tr>
<td><strong>Up to the minute information</strong></td>
</tr>
<tr>
<td><strong>Radio and TV can in theory provide quality exemplars of new pedagogic practices &amp; introduce a range of new pedagogies and classroom activities.</strong></td>
</tr>
<tr>
<td><strong>Quality books are costly.</strong></td>
</tr>
<tr>
<td><strong>Up to date material difficult to access</strong></td>
</tr>
<tr>
<td><strong>Most professional books do not incorporate subject knowledge updating</strong></td>
</tr>
<tr>
<td><strong>Easily worn with frequent use.</strong></td>
</tr>
<tr>
<td><strong>Information can’t be used in classroom except by reportage; Quality of educational material in practice variable and is ‘wholly one-way’ input.</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mobile Phones including: contacts SMS¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personal and Professional Communication, via SMS messages &amp; voice calls</strong></td>
</tr>
<tr>
<td><strong>Personal</strong></td>
</tr>
<tr>
<td><strong>School</strong></td>
</tr>
<tr>
<td><strong>Voice calls allow for in depth, immediate and personal/professional communication.</strong></td>
</tr>
<tr>
<td><strong>Voice calls can be expensive, especially internationally.</strong></td>
</tr>
<tr>
<td><strong>SMS is limited to a small number of characters (160)</strong></td>
</tr>
</tbody>
</table>

¹ 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.
## Appendix 2 DEEP teachers uses of ‘ICT Toolkit’ (Note – italics indicate unexpected findings)

<table>
<thead>
<tr>
<th>Project ICT Toolkit</th>
<th>Teacher Development Uses (including curriculum &amp; pedagogic purposes)</th>
<th>Types of teacher knowledge to be developed</th>
<th>Comparative strengths of digital devices</th>
<th>Limitations and requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Laptop</em>&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Personal activity</td>
<td>Personal</td>
<td>Flexibility - serves a range of personal, professional &amp; pedagogic purposes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- developing ICT skills</td>
<td>School</td>
<td>Range of uses - can be extended and adapted by additional software or hardware</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- communication</td>
<td>Subject</td>
<td>Mobility – enabling use in classroom / home / teacher workshops / church / hospital etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- formal CV’s, job applications</td>
<td>Pedagogic</td>
<td>Ownership- different user accounts enables a number of users to have a sense of ownership &amp; personalisation, as well as fostering collaboration.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- pursuing personal interests e.g. study</td>
<td></td>
<td>Information storage system -stores, organizes and archives data &amp; artefacts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- supporting own children’s learning</td>
<td></td>
<td>Operates without external electricity supply (albeit for a short time).</td>
<td></td>
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<tr>
<td></td>
<td><strong>Professional study</strong></td>
<td></td>
<td>Can integrate seamlessly into a classroom setting (at teacher or pupils’ desks), /be moved around as required.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- course materials study</td>
<td></td>
<td>Enables curriculum activity, not</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- subject knowledge updating</td>
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<td></td>
<td>- studying examples of practice</td>
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<tr>
<td></td>
<td>- use and creation of planning tools</td>
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<td></td>
<td>- using &amp; making classroom resources</td>
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<tr>
<td></td>
<td>- obtaining reference information</td>
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<tr>
<td></td>
<td>- carrying out independent research</td>
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<tr>
<td></td>
<td><strong>Professional Communication</strong></td>
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<tr>
<td></td>
<td>- collaborative working (partners from the same</td>
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<td></td>
<td>school working together at the computer)</td>
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<tr>
<td></td>
<td>- collaborative working (with peers at other</td>
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<td></td>
<td>schools, with the project team)</td>
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<tr>
<td></td>
<td>- document sharing / development</td>
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<tr>
<td></td>
<td>- displaying work (teachers and pupils) to</td>
<td></td>
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<tr>
<td></td>
<td>parents, teachers and governors.</td>
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<tr>
<td></td>
<td><strong>Classroom uses</strong></td>
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<tr>
<td></td>
<td>- learning resource</td>
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</tr>
<tr>
<td></td>
<td>- reference library (e.g. thesaurus / dictionary/encyclopaedia)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Curriculum/ Pedagogic activity</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>- composing texts and multi-media</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- presentation to authentic audiences</td>
<td></td>
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</tr>
</tbody>
</table>

2 In the project, laptops were made available only to teachers in South Africa, via corporate sponsorship
• 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
• community projects
• entrepreneurial development

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)
<table>
<thead>
<tr>
<th>Desktop</th>
<th>As for laptop</th>
<th>As for laptops</th>
</tr>
</thead>
</table>
| Correspondence with official bodies (telecoms, local authorities, grant applications, bills, letters of complaint, service providers, etc.). | Since permanently ‘situated’ at a particular location, desktop less likely to be damaged ‘in transit’ than a laptop. Cables and peripherals may be permanently connected, saving time in ‘setting up’ for use. May be more robust in design and construction, than laptops. May have larger displays than comparably priced laptops, making them more suitable for some forms of group-work or whole class teaching. | Requires permanent external electricity supply Large and fixed physical can obstruct lines of sight for teachers and pupils Classroom organisation is ordered around location of equipment, not the curriculum activity; even more so when computers are being used see a classroom with ten desktop computers in it, a computer suite. |}

---

3 In the project, desktops were available to Egyptian teachers, as part of the standard ministry specification for media labs.
in securing the room, or a
time to move computer to a
strongroom (or local ho
time used.

Moving desktop comput-
way involves a high risk of
machines or people) and
demanding set-up / take
down costs.

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

- word processor
- spreadsheet
- web browser (including audio, video and animation viewing)
- camera and image viewer
- audio recorder / player
- games
- diary
- contacts
- ‘beaming’ (infrared document transfer)
- docking station for handhelds

Many similar functions to desktop/ laptop computers as above. In addition support anywhere – any time learning (e.g. on buses). Additional functions:

**Personal & Professional Development:**
- Readily accessible learning resources
- E-books enable personal learning, study, planning and information- material can be bookmarked, highlighted, annotated and text extracted.

**Classroom Use:**
- 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.

**Curriculum and pedagogic use**
- 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).
- photography
- voice recorder (for language work and recording information & events e.g. Mark Shuttleworth visit).
- support for field work / school trips
- facilitates collaborative work, both for groups of pupils and of teachers – device small, easy to pass around.
- collaborative work encouraged by quick and simple facility of ‘beaming’ electronic notes and other artefacts.

Mainly personal and pedagogic, but research findings indicate strong potential for subject and school knowledge.

**Ultra-mobility**
- ‘Anywhere – anytime’ learning
- Flexibility - serves range of curriculum and pedagogic purposes
- ‘Personal’ computing – constant access and a sense of ownership, gives teachers liberty to ‘play’ & explore “…it is my companion.”
- sense of ‘personal ownership’ encourages teachers taking care of device.
- Runs for several hours continuous use (often equating to several days / up to a weeks use)
- remarkably robust in the challenging contexts of this study.
- teachers feel safe and secure carrying these ‘invisible’ devices, compared to conspicuous and attractive laptops.

**Requires regular (daily / depending upon use) rec**

Prone to total data and application loss upon battery failure.****

Synching with main comp be prone to failure.****

Small screen size requires of educational content designed primarily for larger comp****

Limited storage capacity (media)****, although use increasingly inexpensive capacity memory cards to overcome this.

---

4

****with the particular handhelds used in the study
<table>
<thead>
<tr>
<th>Mini-cameras</th>
<th>Pedagogic</th>
<th>Personal</th>
</tr>
</thead>
<tbody>
<tr>
<td>creating &amp; recording resources for classroom</td>
<td>very small form - can easily be kept ready for use</td>
<td></td>
</tr>
<tr>
<td>classroom literacy activities</td>
<td>easily shared (taking &amp; viewing)</td>
<td></td>
</tr>
<tr>
<td>documenting pupil progress</td>
<td>ideal for fieldwork</td>
<td></td>
</tr>
<tr>
<td>objectifying experiences (teacher and pupils) to help critical reflection</td>
<td>doesn't require separate batteries or charging</td>
<td></td>
</tr>
<tr>
<td>scientific and social sciences project work and field work.</td>
<td>&quot;invisible&quot; and secure</td>
<td></td>
</tr>
<tr>
<td>facilitates displays, presentations, and teacher and pupil portfolios</td>
<td>no costs in film development</td>
<td></td>
</tr>
<tr>
<td>displaying school work to teacher / pupil peers, principals, governors and inspectors. Important in involving parents in settings where adult illiteracy is high</td>
<td>instant &amp; share-able images, readily integrated into other documents</td>
<td></td>
</tr>
<tr>
<td>personal photography (family/friends etc)</td>
<td>minimal ongoing costs</td>
<td></td>
</tr>
</tbody>
</table>
| | | low resolution images
  | shutter delay can mean you can't capturing the intended moment | no flash
  | no flash | relatively low quality image |
Fig. 19a

Fig. 19b

Appendix 3 a and b
Appendix 4 c and d
An active partnership between the Open University, UK and University of Fort Hare, South Africa, has been ongoing for more than a decade (see http://open.ac.uk/deep/iau).

The global South encompasses the following countries: Africa, Latin America, the Middle East, the Caribbean, Asia and the Pacific.

In Phase 2 the project reach is being upscaled to 72 schools (country wide in Egypt); new countries (e.g. Tanzania and Bangladesh) will run pilot projects; more research is being carried out specifically on hand held use (see www.open.ac.uk/deep/deeper) and video conferencing (see www.open.ac.uk/deep/deepa).

The term “Information and Communications Technology” (ICT) encompasses 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)

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.

In Egypt participating teachers made use wherever possible of existing technologies in their schools; in addition they were each provided with hand held computers and an all in one printer/ scanner/ photocopier.