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Do new information and communications technologies have a role to play in the achievement of Education for All?

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Abstract

Many commentators have suggested that the use of new information and communications technologies (ICT) has significant potential in providing access to, and improving the quality of, teacher education. Such an idea is particularly relevant for the global south it is argued, where tens of thousands more qualified teachers are required if universal primary education (UPE) is to be achieved. This paper explores six arguments commonly used to critique the relevance of ICT for development, encompassing technical, cost, philosophical, cultural and pedagogic issues. The arguments are categorized as the 'technological' view; the 'donor' view; the 'anthropological' view; the 'standard' view; the 'individual' view and the 'transmissional' view. Drawing on empirical research into ICT and teacher education in Sub Saharan Africa, including the work of the Digital Education Enhancement Project (Leach, 2006) six responses are used to review these arguments ('developmental', 'democratic', 'cultural', 'deep', 'community' and 'pedagogic'). The author concludes that this contemporary data offers new ways of thinking about such debates and concludes with recommendations for policy makers, educators and the donor community.

Section 1   The Global Challenge

The Education For All Agenda

Over 100 million children worldwide go without primary schooling. In almost all respects, the challenge of universal primary education (UPE) (http://portal.unesco.org/education/) is greatest in Sub-Saharan Africa (SSA). Four out of every ten primary-age children do not go to school (UNESCO, 2005). And only a small proportion of those who do attend school reach a basic level of skills.

Running parallel with this momentous problem is a growing imbalance between the output of trained teachers, particularly in low-income countries, and the demand as primary provision is necessarily expanded. A third of existing teachers in sub Saharan Africa are untrained. Of the thousands recruited each year, they largely have inadequate subject knowledge and little if any pedagogic preparation. Teacher supply in Africa now also has to reckon with the consequences of HIV/AIDS, since teachers are not exempted from the pandemic (Bennell, 2005).

The scarcity of trained teachers is greatest in rural areas since experienced professionals tend to relocate to towns and cities as soon as they are able (Mulkeen, 2005, Hedges, 2005).

These training challenges also need to be seen in the context of concerns about the quality and relevance of current teacher education systems in many SSA countries - and hence of the quality of classroom practice. 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). A recent study by Dembélé and Miaro-II (2003) indicates that unhelpful teaching practices and rigid, chalk-and-talk, teacher- dominated pedagogy remain the norm. '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' (Dembélé and Miaro-II ibid.p.6).

It is clear that existing institutions of teacher education are unable to cope with the scale and urgency of these issues; creative and radical solutions to the problems need formulating (Dladla and Moon, 2002). In this context many argue, the thoughtful use of new information and communications technologies (ICT) has significant potential in widening access to, and improving the quality of, teacher education in the global south[i] (Dhanarajan, 2001; Marker, 2002).

The Digital Education Enhancement Project

Aims, principles and key research questions

Against this background the Digital Education Enhancement Project (DEEP) is investigating the use of ICT for teaching and learning in the development context (http://www.open.ac.uk/deep) in line with the aims of the Education For All (EFA) agenda. This research has been funded by the Department for International Development [DFID], Microsoft South Africa (SA), Hewlett Packard and bridges.org.

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 and improve their knowledge and sense of professionalism. 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?

Four theoretical principles underpin the research, informing both research design and project activity:

- *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

Overview of the project

Inkanyezi [glowworm[ii]] is the Xhosa name for DEEP's first programme in Eastern Cape Province, South Africa (SA), This programme was 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 [iii]. It focused particularly on improving the quality of teaching and learning in literacy, numeracy and science (Leach, Klaas, Mnqgibisa, Power, 2002). All schools in the project serve disadvantaged communities and most are situated in rural settings where project participants had no prior experience of ICT. Schools have negligible resources, apart from a small number of books and recycled artefacts for basic numeracy and science work, such as beakers, cardboard boxes, bottles and bottle tops. Class sizes vary between 40 and 80.

Six of the schools have no electricity and five no telephone connectivity. Many of the classrooms 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. In one school, floorboards from some of the classrooms had been removed by members of the community to provide firewood during a cold winter or for building materials for makeshift housing.

Project Activity

Participating teachers worked in pairs to carry out and evaluate a sequence of curriculum focused, professional development activities. These included classroom activities to be carried out with selected classes. A 'Professional ICT Toolkit' was assigned to each participating school/teacher pair, carefully chosen to facilitate the project's pedagogic purposes (1) to develop teachers' professional knowledge; (2) improve classroom practices; (3) to be easy to use in remote schools with little or no infrastructure:

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)

Teachers learned to use the digital toolkit at a week-long, curriculum focused launch workshop (see Leach, Ahmed, Makalima, Patel, Peters and Power, 2004). The Toolkit included high quality, multi-media materials including classroom resources and planning

tools. A support structure of local cluster meetings and termly workshops was integral to programme design.

DEEP assigns no primacy to any particular technology, but rather, is interested in its fitness for pedagogic purpose. A broad view of ICT was taken within the programme, encompassing traditional communications technologies already familiar to teachers, such as radio and TV, as well as newer forms such as laptops and video conferencing.

<u>Data collection</u>

A range of data was gathered by the small research team across a 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. This rich data helped to minimize problems with self-reporting on ICT use, as identified in the literature by Cox (2003),

<u>Headline findings</u>

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:
- 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. They showed high levels of motivation in using ICT both within and out of lessons; teachers, school principals, parents – and students themselves reported a range of achievements, including improvements in literacy and science learning.

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.

Section 2 Current debates

'Seizing the opportunities of the digital revolution is one of the most pressing challenges we face […] First, our efforts must be based on the real needs of those we are seeking to

help. They must be fully and genuinely involved.' (UN Secretary General, Kofi Annan, General Assembly 2002)

Is there a role for new technologies in the provision of teacher education in Sub Saharan Africa? What is the evidence?

During the dissemination phase of the DEEP research outlined in Section 1, policy makers, donors, ICT specialists and aid agencies consistently raised a range of issues in relation to these two questions concerning ICT for educational development.

These issues were documented by the DEEP researchers and are discussed in this section, categorized in terms of six 'views':
- the *technological* view – 'ICT access and infrastructure is too undeveloped in rural Africa';
- the *donor* view – 'basic needs such as water and food should be the priorities for rural communities, not ICT';
- the *anthropological* view – 'ICT is too complex for rural teachers and their pupils';
- the *standard view* – 'state of the art technology is unnecessarily costly for rural contexts';
- the *individual* view – 'hardware will inevitably be lost, broken or stolen';
- the *transmissional* view – 'ICT adds nothing distinctive to effective teaching and learning'.

A reply to each view is also presented, characterized in turn as the *developmental, democratic, cultural, deep, community and pedagogic* response. Each response represents the view of the DEEP research team (including the author of this paper). Each reponse is supported by evidence from the DEEP research findings, amplified by related literature from the field of study.

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1. The 'Technological' view
'Half of the world's population has never made a telephone call, much less accessed the Internet. Planning for ICT use in teacher training in poor, rural contexts is unrealistic in the foreseeable future'.

The 'Developmental' Response
'No-one can ever believe that rural school educators and learners can use computer technology the way we do. We are so confident and we are so proud of ourselves.'
(Project teacher, Eastern Cape)

Many argue eloquently that the technologies are not sufficiently in place in SSA to achieve the sea change that would make their use for teacher education and practice feasible in the foreseeable future. Kofi Annan, speaking in 1999 to the Millennium Assembly, spoke of the 'yawning digital divide'. 'Visions of a global-based economy and

universal electronic commerce, characterized by the 'death of distance', he said, 'must be tempered by the reality that half of the world's population has never made a telephone call, much less accessed the Internet' (OECD, 1999).

The Eastern Cape context vividly exemplifies this. Data shows that the provincial share of the poverty gap within South Africa[iv] nationally is greatest by far in Eastern Cape[v]. South Africa's GDP per head is $2,500, but within the Eastern Cape falls to $432. Even that figure is a glib average that masks the intense deprivation of many of the remote corners of the province when compared with bustling and relatively thriving areas such as East London, King Williamstown and Grahamstown. In terms of access to and use of new forms of ICT, the picture remains comparable. 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, whilst in the remoter parts of the Eastern Cape this statistic falls as low as 0.1 per 1,000 people – the same is true for access to PCs (Accenture, 2001).

A pre-project survey of DEEP participants' use of ICT, carried out in 2002, revealed that none owned a computer and 14 (58%) had never seen or used a computer. The majority (18: 75%) had never used the Internet (Figure 1). Of those 10 teachers who had prior experience of computers, only 5 had '*occasionally*' used them in relation to teaching; 4 of the 5 worked in the project's three peri-urban 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'.

Fig 1 Teacher 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)

Recent data suggests, however, that this picture is already much changed. Across Africa generally, the technological context is developing fast, even in rural contexts. 'In 1999 there were 1.5 billion telephone lines worldwide [...] while today there are nearly 2.5 billion. In just four years we have added 1 billion lines to the 1.5 billion we had connected in all the years before – and 75% were installed in the developing world' (Utsumi, 2003). In addition, the adoption rate of mobile technologies in Africa is among the highest rates globally, indeed 'the mobile communications sector has to qualify as one of Africa's success stories' (Minges, 2004). Forecasts estimated almost 100 million mobile users in Africa by 2005 (Shapshak, 2002) and although the actual figures and statistics are not readily available at the time of writing, they are likely to be even higher than expected.
South Africa is no exception to this as Figure 2 illustrates.

Figure 2 Comparison of telephones and mobiles phones South Africa 2000-2002

SOUTH AFRICA	2000	2001	2002
Mobile phones (per 1,000 people)	191	242	304
Telephone mainlines (per 1,000 people)	114	111	107

Parallel to this leap forward in respect of access and infrastructure, most governments Africa wide have now established ICT developments as a national priority, including for educational purposes[vi]. In South Africa investment in ICT nationally, including in education, is growing sharply (Fig 3). In 2001 $11,430,000,000 was invested in ICT (5.7% of GDP); Power (2006) notes this represents a spending on ICT of $268.7 for every person living in the country.

Figure 3 ICT indicators: South Africa

ICT indicator	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

Educational policy reflects the hopes for such investment. South Africa's new White Paper on E- Education (South African Department of Education, 2004) sets out the country's intentions 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'. Many new educational ICT projects are being implemented in cities and towns and most provinces have ambitious plans for technological roll out into rural locations, including schools, over the next decade.

Such trends are evident across most countries in Sub- Saharan Africa. In Rwanda, for instance, shakily emerging from the genocide of 1994 that destroyed what fragile infrastructures existed, an ambitious plan is in place to install fibre optic cables countrywide. In addition, a visionary national educational policy on ICT is being developed (Rwandan Vision 2020: http://www.rwandagateway.org/index.php3: url last accessed 17/2/06).

Such evidence suggests it is only a matter of time before widespread connectivity will be possible, perhaps commonplace, even in the remotest areas of sub Saharan Africa. We

argue that those interested in educational development cannot wait until the last school in the last province has electricity before they begin to evaluate and implement good practice in the use of technology. The potential of new wireless technologies, combined with the expanding potential of flexible, mobile equipment is such that, when connectivity in an area becomes available, educators must already understand how it can be used to enhance and transform teacher education and pupil learning (Jordan, 2005).

A '*developmental*' perspective challenges the '*technological view*', taking a broad view of ICT and educational purposes (Unwin, 2005), rather than being solely concerned with technological issues. As new technological possibilities unfold it is important from this view point for educators to ' take risks, take time, be flexible…... to be aware that there is no magic wand to guarantee results in the short term, particularly if initiatives are designed with a people-centered empowering approach' (Weigel, 2005). Rather than taking hardware and software as an inevitable starting point, a *developmental* perspective inquires What forms of ICT? For what purposes? Who will use it? In what contexts will it be used? Will ICT use make current practices more efficient or extend or transform them in some way? How will we know?

The DEEP research illustrates what it is possible to achieve in rural communities, even where infrastructure is fragile, and experience of ICT negligible. From this *developmental* perspective the voices of teachers, students and parents - interested in health awareness, science, literacy, mathematics, the visual arts, local history and the environment – need to be heard above the din of those who define technological literacy in terms of de-contextualised IT skills such as 'inserting a CDROM' or being able to 'use keyboards and other input and output devices'. The concerns of community leaders concerned with the development of expertise in health care, agriculture, entrepreneurialism, civics, and environmental conservation must be given priority above those preoccupied with the process of installing costly computer suites and 'office' based applications.

2: **The 'donor' view**

'*Penicillin before Pentium! In poor, resource challenged environments, priority must be given to food and health needs, ICT is an inappropriate, unaffordable luxury.*'

The 'democratic' response

'*With the arrival of the laptop everyone in the school was overjoyed. The first time I introduced it to my learners, they were so curious and wanted to use the computer right away. Using the computer makes teaching and learning more enjoyable...Animated stories like 'HARE AND TORTOISE' enhance learners' curiosity...I allow learners to translate these stories into isiXhosa, in which they showed great creativity. I'm proud to say that a number of learners have showed tremendous improvement in reading and writing and are really confident with using a computer.*' (*Project Teacher, Eastern Cape*)

A more emotive argument is articulated by those who consider there is a clear-cut choice to be made between daily survival and what they see as unaffordable access to a 'luxury' such as ICT. The 'bread or computers' debate was one of the most hotly contested issues at the World Summit on the Information Society held in Geneva, 2003. Proponents of this view have been generally hostile to the DEEP project's research hypotheses and skeptical of its findings. They are usually members of donor organizations or those who live and work in industrial, western countries such as USA, UK, Germany, New Zealand. Hence I have dubbed it the *donor* view.

The humanitarian imperative of addressing global tragedies such as famine and the pandemic of AIDS is indisputable. A *democratic* response to the *donor view* however addresses the long-term benefits that ICT might afford poor communities. For the poor the real issue is not whether ICT are or are not desirable – since technology is now an irreversible part of the world in which they live. The issue is whether it is acceptable for the poor to be further deprived of opportunities that might improve their livelihoods.

Cawthera (2001) has offered two justifications for expenditure on computers in education in developing countries: (1) they can improve the quality or the quantity (access) of education in a cost effective way (2) ICT is likely to play such an important part in the future of any economy, it demands its own distinctive place in the curriculum. Weigel and Waldburger (2004) identify four aspects of ICT that are 'really new' and which, they argue, make them indispensable to the poorest: interactivity; speed+24 hours many to many; lower costs; integration of different media.

DEEP accepts all these arguments, but is further premised on the proposition that ICT can make some aspects of teacher professional development and pupil learning more efficient and in some circumstances can even significantly extend or transform these processes. (McCormick and Scrimshaw, 2001).

Philosophically DEEP's values are also informed by Sen's (1999) theory of social choice which challenges the belief that 'some forms of human development and progress are a kind of luxury that only rich communities can afford'. If development entails freedom to make choices, which in turn requires knowledge and educational skills, denying such opportunities to particular groups is contrary to the basic conditions of such freedom and implies for such a group an 'unfreedom'. Our *democratic* response is therefore predicated on the importance of providing opportunities for teachers, educationalists and learners of all ages –most especially in remote, resource challenged environments - to explore for themselves the benefits and drawbacks of ICT. To make their own informed choices about the relevance and appropriateness of such new technologies, in their specific contexts and experiences. Research shows that in poor communities the scarcity of trained local personnel (including teachers) and the impediments they face in accessing vital information and enhancing their skills, perpetuates poor health as well as the low educational attainment in such communities, making them less able to cope with the challenges they face (Marker, 2002 p. 8). A democratic response proposes that the potential reach and range of affordances offered by new forms of communication technology is so formidable when combined with knowledgeable teaching and

appropriate strategies (Cox et al, 2004; Selinger and Gibson, 2004) that they offer radically new possibilities for the development of human capital in rural regions.

We are aware of past disappointments with technologies. The DEEP research highlights that educational uses of ICT do need to be strongly grounded in pedagogic principles (InfoDev, 2005), supported by quality resources and professional networks. It emphasizes the importance of:
- **Opportunities for school based, curriculum focused, activities** -school and local community the main site for professional learning; teachers' contexts at the centre of training: focus on teachers and pupils' learning needs;
- **Emphasis on peer learning** –teachers expected to work together in pairs and school clusters;
- **Provision of context specific, high quality ICT resources and local support –** specially designed, professional development materials, opportunities to explore model lesson plans, materials, video clips and web sites; using local language medium, local curriculum, national and local settings (Leach, 2006).

Extensive, though to date largely anecdotal, evidence (Weigel and Waldburger, 2004 p.223), confirms that ICT can support poorer communities in making choices, voicing opinions, demanding rights, having more power over their lives (Marker, 2002, page 8). Studies also show that when 20% of a population has the ability to exchange news and ideas through access to cell phones and text messaging, dictatorial or totalitarian regimes find it hard to retain power (Commission for Africa, 2005). Research suggests that ICT use enabled teachers to rise above the immediate minutiae of the everyday, ameliorating to some degree the sense of 'stuckness' and isolation that so often dampens teacher initiative and sense of agency in poor communities. Future planning became a much more feasible possibility, we have dubbed this the 'Intambanane[vii] effect'. In this sense a *democratic* perspective focuses on how educators in rural environments, traditionally most excluded from quality professional development and resources, can be empowered to be creative users of ICT, rather than passive onlookers of the Networked Society (Castells, 1996).

3: The 'anthropological'[viii] view

'Teachers and school children unused to ICT will find sophisticated digital devices too complex. In any case books are needed before computers'.

The 'cultural' response
'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. The story is about how the giraffe got it long neck. We will share the story with all of you when it is done'. (E-mail from project pupils)

If the *donor* view somehow implies a notion of 'the other', the *anthropological* view makes this explicit. Proponents of the *anthropological* view argue that teachers and

learners in rural communities need to have a gradual, linear experience of communication technologies much in the order in which they were invented: first books, then radio and TV, and only then computers. To 'jump' technologies is both unnatural and pedagogically unsound, it is argued. In any case it will inevitably lead to failure, since complex ICT devices will be too complex for rural teachers to master.

More than a century ago Pitt-Rivers (1891) made full use of the communicative powers of museums by inventing 'typological displays' of tool forms precisely to demonstrate empirically this view of the progressive and technological nature of human evolution. His explicit political agenda was to 'educate the masses that the Law of Nature 'makes no jumps' (Pitt Rivers 1891:116). As a result of this work, dioramas of early human technologies can still be visited in museums of *natural history (*including those depicting survival technologies 'still' practiced in modern times, including in Africa). As Dobres (2000) points out, such displays are intentionally symbolically powerful –persuading the viewer that the primary laws to which technological evolution and use responds are 'natural' rather than cultural. 'In a colonially expanding period of European history when capitalist enterprises were coming increasingly into contact and conflict with indigenous communities, the primitive or 'natural' qualities of non – western peoples as expressed by anthropologists served to justify their political dominance and exploitation by more 'civilized' peoples in the name of progress' (Dobres, 2000, p.29).

The end of the nineteenth century in which Pitt Rivers was working, was a time of rapid change. Not only was the world coming to be united in a net of steel, telegraph wires, and ideologies of progress, but also, and perhaps more significant, for the first time in history growing numbers of people in societies around the world – societies that differed greatly in structure, cultural practice, and historical experiences – were coming to the realization that their daily experiences and the structural conditions of that experience were drifting apart. The printing press, the telegraph, the telephone all, in an earlier age, changed people's conceptions of the world. Such a process characterizes developments in communications technology today. Erlmann (1999) argues that within our modern forms of consciousness, contemporary changes engender - and are often in turn expressed in - a mirror dance between both Europe and Africa's images of the 'other'. Each retains many of the legacies of the 'global imagination' developed during the late nineteenth century. Most notable is the 'intertwined, persistence of fantasies of an abused and defenseless Africa and, inextricably, a certain heroic image of Europe and the individual' (Erlmann, ibid. p. 24). It should be no surprise if we detect something of this view of 'otherness' in the way new forms of teacher education - as well as new technologies - are sometimes perceived. Especially given the persistence of strong mythologies about technological development as in some way reflecting an objective, 'natural' form of human progression.

A growing number of educational projects (e.g. Bose, 2004; Siddle, 2005; Finkoama: http://www.fiankoma.org/ftp/) vividly demonstrate how erroneous the *anthropological* view is. Such projects illustrate that new forms of technology-enhanced practices offer opportunities for more realistic and rational thinking about what is humanly possible. They also provide a *cultural* response to the anthropological view, demonstrating that

technologies are the tools of culture (Bruner, 1996), which develop meaning through authentic use in the lived life of groups and communities. Project teachers and pupils participating in Inkankwezi quickly learnt to appropriate ICT for a range of personal, professional and pedagogic purposes and grew significantly in their confidence to use ICT within the curriculum. Feedback provided evidence of creative use of the lap tops beyond the walls of the school - by school principals, other colleagues, friends, children, local organizations, sisters, girlfriends, husbands: '*I've helped other teachers, made agendas for meetings and even typed an assignment for a colleague'; 'we had to ask my 6 year old son's friends what word he might have used as a password to lock us out of the computer [laughter]'; 'of course we use solitaire, we want to get more games, everyone likes them'*. The degree to which groups in the wider communities shared and used a range of digital devices was unexpected across all settings in the Eastern Cape, and was indeed greater than teachers' personal use. Such use ranged from an application for a sheep shearing shed for a local community woolgrowers association, the constitution of a local sewing project, enquiry on an unpaid death claim, production of the obituaries of local residents, agendas, tickets and programmes for an AIDS awareness youth rally.

Research confirms that the way in which teachers use ICT within educational communities, has a far greater effect on learning than physical access (Cox et al, 2004), and is wholly unrelated to linear notions of progression. In the Enlaces project in Chile (Potashnik, 1996), thousands of pupils used an imaginative computer network simulating a village community to learn to read for the first time. They also created the first ever dictionaries in their home languages. Within DEEP, resources such as encyclopaedias, thesaurus, dictionaries, quality reference scientific material, illustrated collections of folk stories, and up to date subject materials were made accessible as electronic documents to large numbers of adults and children. A *cultural* view of the relationship between learning and technology is crucial: emphasizing as it does pedagogy which best meets all learners' needs. A pedagogy researched, determined and owned by teachers and the community, who alone are able to ensure that the way in which new technologies are used, honours their needs and culture.

4: The 'standard' view
'*State of the art technology is too costly for poor rural primary schools and their communities*'

The 'deep' response

'*The community too have been using the laptop and printer/copier to their benefit. They have produced posters, invites, letters, funeral announcements etc by using the laptop and printing out, and then copying them. The community as a whole has benefited and they have contributed financially to the costs of ink and paper'*. (School principal, Eastern Cape)

The idea that the most contemporary and powerful forms of ICT are being used in poor, rural schools has led to heated debate about such devices being too costly for resource challenged settings. Many of those opposed in principle to ICT solutions in rural Africa have often seen the cost issue as the trump card. Whilst the *donor* and *anthropological* views might be questioned philosophically - or on grounds of equity and entitlement - the high initial costs of ICT hard ware and software, as well as the costs of sustaining these over time, are considered by many to close debate.

No objections however, were raised by critics in relation to the use of refurbished computers within DEEP 's Egyptian programme. This was unsurprising to the research team. Indeed it is soon likely to be *standard* for secondary schools in towns and cities in developing countries to have a classroom adapted for computer use, mostly equipped with refurbished machines (Cawthera, 2001). Cawthera (ibid) makes a distinction between (1)'basic' ICT provision (i.e. second hand computers provided free - usually from a western NGO), (2)'basic plus' provision (i.e. second hand computers also usually from a western NGO, refurbished and upgraded with provision of training) and (3)'deluxe' provision (i.e. new equipment funded by a central government scheme or by parents/ school fees). Basic provision, will be the most common, Cawthera argues. Such analysis is confirmed by well-publicized investments in refurbished computers for Africa. Digital Links International (http://www.digital-links.org/), for instance, 'has helped SchoolNet programmes in several African countries to draft funding proposals in order to kick start their role as distributors of refurbished computers'. In 2004 RM plc, a leading provider of computer equipment in schools in the UK, became Digital Links' biggest donor of computers to date, supplying them with 7,000 refurbished PCs'. SchoolNet's approach is outlined in their report: 'Treat Refurbs and Africa with Respect: A Research Report by SchoolNet Africa' (SchoolNet, 2003)

DEEP's original research design did not encompass cost issues. The focus of its research was pedagogic, looking to a future when ICT hardware would be more affordable. In any case, cost analyses were already a main focus for other researchers (e.g. Osin, 1998; Perraton, Creed and Robinson, 2002; Cawthera, 2001). Persistent questions about costs however, proved to so overshadow curriculum issues that the research team realized it was crucial to investigate these. Power (2006) used a Total Cost of Ownership framework (Moses, 2004) to interrogate costs. He found that DEEP's modest, but state of the art ICT Toolkit was likely to be significantly more cost efficient for a primary school, than maintaining even a 'free' suite of refurbished desktop computers (Power, 2006, p.4).

Cost effective comparisons are complex and difficult to make and much more work is needed here (InfoDev, 2005). A *deep* response to the *standard* model suggests however that what is achievable by means of an 'any time, any place' powerful mobile computer is also likely to be hugely different to what can be achieved by means of a refurbished computer in a fixed location (Leach and Power, 2006). Certainly purposes are key to any comparative analysis. Project data illustrates the way in which the DEEP ICT Toolkit served concurrently as (1) a means of developing teachers' professional knowledge, (2) as a pedagogic tool for enhancing students' scientific, communication and information literacy and (3) as a community tool. Indeed in cost effectiveness terms, the research

suggests, small rural communities may derive a much greater incremental benefit from modest, state of the art ICT provision than richer schools saturated with resources (Cawthera, ibid. p.30).

Policy makers' opinions of what is or is not 'affordable' might also alter if ICT were no longer seen as a bolt- on resource 'kit' to support ICT skills, but rather as an essential dimension of quality teacher training, pupil learning, school improvement and community growth. In ensuring high levels of usage for project equipment, DEEP's multi-user approach provided evidence of proposals made by Cawthera (ibid) for optimizing the cost-benefit balance in providing ICT to schools. Collaborative professional activities for instance, that allow teachers to practice new approaches to learning, can generate high levels of lap-top usage, more difficult to achieve with desk top PCs in a fixed location. Pairs of teachers using the machines double the number of opportunities for equipment use. Teachers can use laptop and handheld computers out of school hours to discuss and develop opportunities for integrating ICT into lessons (Figure 4). The portability of hand held devices and laptops also means they can be used in the evenings and at weekends, for ongoing professional development, teacher meetings, personal learning and community activity.

Figure 4 Where DEEP teachers used project laptops
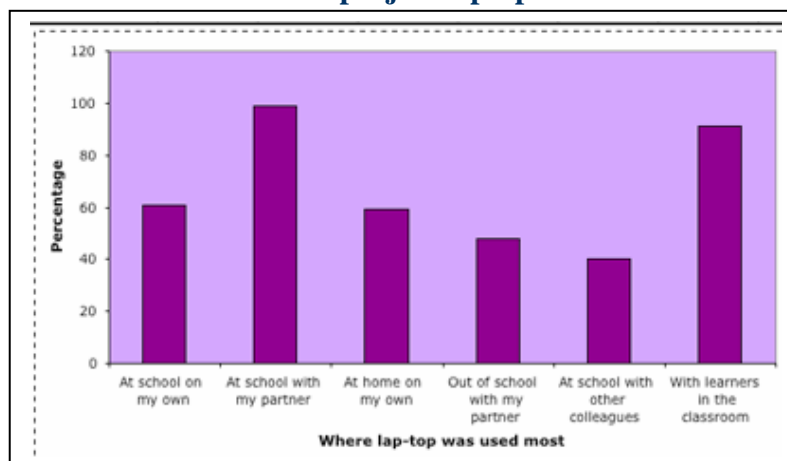
Rather than a single computer lesson occurring at occasional intervals during the week for skills development, DEEP's ICT- enhanced curriculum activities spanned several days of continuous use, including fieldwork outside the classroom. Within lessons, pairs or groups of pupils therefore were able to have 'extended' use of a single laptop in rotation.

A *deep view* of powerful mobile ICT, orientated towards purposeful learning, we propose, is at least as cost-effective as *standard,* computer lab models. And for a similar investment, may be capable of generating a range of highly effective additional outcomes supportive of the EFA goals.

Other issues are also raised by our research in relation to the *standard* model of refurbished PCs (prone to failure, power hungry, often limited in multi-media

capabilities) and computer suites (requiring expensive security solutions and limiting of pedagogic strategies) in rural schools. Such practices we argue, need to be re-assessed on environmental as much as on financial and educational grounds. The U.S. National Safety Council estimates that 315 million computers became obsolete in the United States by 2004. The Director of the Silicon Valley Toxics Coalition argues that those computers contained a total of 4 billion pounds (lbs) of plastic, 1.5 billion lbs of cadmium, 1.2 billion lbs of chromium, 1 billion lbs of lead, and unknown amounts of mercury and brominated flame-retardants. Only 11% of those computers were recycled in 1998, according to figures available from the National Safety Council; if placed in landfills, the lead can contaminate drinking water supplies (Betts, 2001; Arthus-Bertrand, 2002). When western countries are recognizing the imperative to shift from a throwaway economy, with engineers designing products that can be recycled and solar powered, we need to question why computers containing such a diverse array of potentially toxic materials, difficult to recycle, are being donated in large numbers to educational institutions in Africa's cities and towns. More research urgently needs to be done on cost effective, environmentally sound alternative ICT solutions, for north and south alike.

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5. The 'Individual' View

'The technology will be stolen, lost or broken'

The 'Community' Response

'There is a lot of vandalism generally- we have used the new computers to argue the case for good security, which we need regardless of the laptop. Communities need to take this issue seriously.'(Eastern Cape School Principal)

Security is a concern for any ICT project wherever implemented worldwide. The extent of this as an issue within the DEEP, however, could not be fully assessed until project close, when outcomes had been fully reported and corroborated. Research on security in rural contexts is not generally available. The 'common sense', or what I term *individual* view suggests that costly computers located in poor communities will inevitably be stolen. This view relies on assumption rather than evidence, together with a range of preconceptions based on individual anecdote. In the event, evidence led the researchers to refute the individual view and develop a *community* response.

DEEP participants were acutely aware that a laptop was worth more than an annual teacher salary and probably double the annual income from school fees. The issue of security was therefore high on the agenda as a formal and serious problem within the project. The first Professional Activity ('*Why ICT- for my learners, my school and my community?*') and the first school based Classroom Task ('*Introducing the computer and the project to our school principal, school staff, students and parents*') were designed to provoke debate among participants. A consensus was reached that ownership of the

project by the school and local community was key. If learners, parents, grandparents, governors, uncles and aunties understood the importance of the project, hopefully they would also share in solving security issues. In practice each community worked on a different solution as appropriate – usually as a result of community meetings. 'We keep the lap-top at home – at the weekends when we go back to our families we store it at the principal's house'; 'We lock the lap-top in the strong room at school'. One school used market bags to discreetly carry equipment to and from village homes at the end of each school day - pairs of students worked a rota for collecting and returning the equipment.

At project end, of the 149 digital devices dedicated to the project (18 lap-tops; 52 handhelds; 24 all in one printer/ scanners; 52 add-on cameras; 3 digital cameras) 143 remained in working order. 4 of the new lap-tops had to be replaced because of non-functionality (unconnected to damage or mis-use by project teachers); 2 of the hand-held devices were stolen: one during a domestic house robbery in Berlin, Eastern Cape some 40 miles from the local school community, and one from a researcher's car in Sussex, UK. Although it is not possible to quantify precisely, the data suggest that the 'survival' rate of project equipment was no worse than one might reasonably expect in schools anywhere in the developed world - despite harsh working environments, inexperienced users, a lack of direct technical support, and use by large numbers of students. The fact that equipment survival was no worse, and after factoring in high levels of usage, may even be better than that for schools in more developed contexts challenges the view that ICT is an inappropriate technology for rural settings. It also illustrates the care teachers and students jointly took with costly equipment, and their determination to keep this valuable toolkit in good working order for the *community* as a whole. It is important to note that at the time of writing equipment is still regularly monitored and in use. 10 of the original 12 schools are now using additional hand held computers in a new phase of the research alongside the original equipment (http://www.open.ac.uk/deep/Public/web/projects/extending.html).

6: The 'Transmissional' View

'There is no learning that cannot be achieved by other, less high tech means.'

The 'Pedagogic' response
'what struck me so forcefully was how small the planet had become during my decades in prison.....[technology] had shrunk the world and had in the process become a great weapon for eradicating ignorance and promoting democracy.'
(Nelson Mandela, 'Long Walk to Freedom')

Several comparative studies have been made of communications technologies (e.g. print, audio, radio, TV, computers etc) for teacher development in the African context (e.g. Perraton, Robinson and Creed, 2002). In such analyses ICT is always defined as desktop computers/ computer suites as set out in the *standard* view. A *transmissional* view of teaching and learning generally underpins such comparisons, often combined with a dated notion of 'distance learning'. From this perspective the learning process is a one-

way street of information giving and receiving - from 'instructor' to 'learner' via course materials. ICT is seen as one more form of 'instructional media', along with print, radio, TV and CD-ROMs.

DEEP's *pedagogic* response to this *transmissional* view of learning and technology is that ICT has the potential to change the very nature and processes of pedagogy. Technology enhanced activity 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.

At project end the majority of teacher participants reported that they considered ICT to be 'important' or 'very important' (88%) for teaching and learning. Technology enhanced learning was seen to be a communal, creative, empowering process - and one of productive activity.

Professional activity

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. The DEEP research has revealed just how exhausting and de-motivating it can be for teachers to maintain such intellectually demanding activity day after day with limited, inflexible resources and rudimentary planning tools. Most teachers in a developing context lack the professional toolkits that teachers in the global north take for granted. Such toolkits extend the reach and quality of what it is possible to achieve (e.g. planning templates; curriculum documents; example lesson approaches; dictionaries; thesaurus, wide ranging resources and softwares etc.).

DEEP participants reported that ICT had impacted on their ability to plan lessons; a majority (77%) reported 'high' impact. They used ICT to obtain resources (77%); prepare teaching materials (62%); prepare lessons (62%); produce teaching resources (51.5%); administration (34%). Teachers particularly reported on the expansion of professional capabilities as they used and got used to the laptop and/or hand-held computer. Portable computing offered new possibilities in terms of access to 'anytime, anywhere' professional activity. Within classrooms ICT facilitated: collaborative working (74%); presentation of material (54%); independent learning (31%), individual and group investigations'; 'research (e.g. of local species)';'the practice of ICT skills'; 'working with spreadsheets'; 'problem solving'; 'photography';' use of the Internet'; 'story and poetry writing'. ICT enabled teachers, irrespective of their physical isolation, to access, use, develop, discuss and improve some of the essential artefacts of practice: planning

tools, case studies of effective subject teaching, model schemes of work, approaches to classroom organization with large classes and so forth.

Group learning

The DEEP professional development materials encourage the use of group work. The theory and research that suggests learning is effective where learners are able to jointly develop concepts together is well rehearsed. But there was also a pragmatic value for DEEP, in that group work enabled teachers to make maximum use of a few digital devices by a large number of pupils. Another dynamic was also reported by some teachers. They have a small number of digital devices. These devices cannot be used didactically with classes of forty to sixty learners: it would not be possible to make presentations to an entire class on a laptop or handheld. This dilemma led project teachers to two practice changing conclusions: firstly, that they must put the tools in the learners hands; secondly, that some groups of learners must work together using the digital devices for extended periods of time, whilst others were engaged in 'non-digital' activities (http://www.open.ac.uk/deep/Public/web/caseStudies/groupWorking.html).

The constraint imposed by a single laptop compelled teachers to move away from didactic teaching and develop alternative models of practice. One pupil commented '.. helping each other learn makes it much easier; children only learn from other children'. When asked, 'what do you think is the ideal computer set up for a class of 40+, supposing there were unlimited resources?' she replied 'I would go for a mix. Sometimes what you get from a lap top or handheld is different. If you use all of them together you just come up with something brilliant. One laptop for 5 people…that would be 8 laptops [for a class of 40]. I would go for the laptops. And the micro scanner and all of those things. And one digital camera to share'. Questioner: 'Not two to a lap top or even one per learner?' 'No that would be selfish. And we learn to work together. Because that is what we should be doing, working together'.

Student achievement

The majority of teachers (90%) considered that project activity has been important 'for improving student achievement and motivation'. When invited to say 'what aspect of student learning has most improved?' answers varied considerably, clustered around the areas of: communication; curriculum related learning; IT skills; social learning; approaches to learning; personal development; confidence and motivation. Feedback from school principals particularly emphasised students' increased motivation towards learning: 'Learners are inquisitive', 'learners have become more curious'. Some remarked on the development of specific skills ('learners are encouraged in spelling, sentence building, science awareness'; 'parents are pleased that their children are taking literacy seriously'), as well as a sense of personal development and self confidence ('my learners have had an opportunity to see, touch and use the computer for the first time in their lives; it widens their knowledge, they are willing to speak and willing to attend the classes, it widens their knowledge (sic).)' Formal tests were not carried out with students, however, more than half of project teachers and school principals volunteered

during interviews that student test scores had increased in end of year tests. 'Those learners who are exposed to this project are more advanced, this edge helps them move more quickly', 'I witnessed that the exams began to increase for maths, I will photocopy one of the improvements in grades for you to see.'

Conclusions

This paper makes three propositions:
- the worldwide challenge of Education For All has a concomitant challenge to develop teachers that will make learners' experience of schooling both meaningful and productive;
- given this context, there is a need to research and evaluate new models of teacher education which exploit the potential of new forms of technology;
- teacher educators worldwide can contribute to an investigation of new models and approaches, a debate based on considered, evidence - based research.

I have used research evidence to challenge six commonly voiced views about ICT in developing contexts and discussed a series of alternative responses. These debates, I suggest, raise the following key issues for teacher educators, policy makers and donors:
- planning for the development of national systems of teacher education and school improvement should explicitly recognize the important role of ICT and its potential for increasing access and improving quality;
- the potential of a range of powerful, mobile technologies needs further research in a wider range of contexts and purposes;
- further evidence is urgently required as to the way in which new forms of technologies, particularly mobile technologies, impacts on the logistics/costs of provision generally for teacher education and school improvement, not just for ICT related training;
- ICT policy and practice needs to be closely matched to local contexts, with a particular focus on classroom relevance, learner achievement and community need.

Across the world, many internationally recognized 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 education is to create a new, international partnerships, discourse and debate, drawing on wide ranging practices and scholarship, and embracing some of the questions and issues raised in this paper. The role of individuals and institutions in creating and working together in this provides an agenda for the next stage of development.

If you would like to discuss or be practically involved in the issues raised by this paper please contact the DEEP research team at: fels-deep@open.ac.uk

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

ii Inkanyezi sisinambuzane esincinane, esikholisa ukuqapheleka ebusuku ngenxa yokudanya-danyaza kwaso. Udanya-cimi esiye simenze uthi "Ndileq' undibambe!". Kokukukhanya okuye kubenomtsalane ebantwaneni. Ayibobungakanani bayo

obubalulekileyo, koko ligalelo layo ekukhanyiseni nakwintsunguzi 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]

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

[iv] i.e. the combined measure of numbers in poverty and their depth below the poverty line

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

[vi] This is consonant with the eighth Millennium Development Goal, 'Developing Global Partnerships'which includes '*making available the benefits of new technologies - especially information and communications technologies*'

[vii] Intambanane is a dancing kestrel in Xhosa- and the name of a school that was particularly successful in the project

[viii] This term is used because the roots of the discipline are in global colonial times, when European and American dominance of overseas territories offered scholars access to different cultures