4D Technologies: appropriating handheld computers to serve the needs of teachers and learners in rural African settings

Conference or Workshop Item

4D Technologies: appropriating handheld computers to serve the needs of teachers and learners in rural African settings

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Introduction

' Globalisation must […] mean justice on a global scale'. (Commission for Africa, 2005, p.22)

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

'…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' Raj Dhanarajan, 2001.

Dongwe Combined Primary School, which has around two hundred pupils, is situated above rolling hills on the outskirts of a sizeable village, 15 kilometres from Berlin, Eastern Cape, South Africa. Across a scrubby path in a small classroom with commanding views across a valley, a meeting of teachers from a cluster group of local primary schools is working on the Inkanyezi project. Seated on low pupil benches they share battery-powered laptops with their project partner; each teacher is also working with a state of the art hand held computer. The purpose of the meeting is to evaluate their progress on the project, as well as to share ideas about pupil achievement and progress. One young teacher shares an animated bilingual intsomi (folk tale) a group of his pupils have created in the local language (Xhosa) and English to support their literacy work, whilst his colleague discusses issues of classroom organisation when using a single laptop with a large class. Teachers from a nearby school demonstrate power point presentations on local animal species, spreadsheet on animal classification, and illustrated poems produced by their pupils in literacy and science lessons.

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

Over100 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. It is clear that the existing institutions of teacher education are unable to cope with the scale and urgency of the demand. Creative and radical solutions to the problem of teacher education in the Global South need formulating (see for example Moon, 2000; Leach and Moon, 2002; Dladla and Moon, 2002; Moon, 2004). In this context we argue, the thoughtful use of ICT has significant potential in helping widen access to - and improving the quality of - teacher education in the developing world. A study carried out by the UK's Department for International Development (DFID, 2002, p. 4-5) concluded that 'properly deployed, ICTs have enormous potential as tools to increase information flows and empower poor people'. 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).

The Digital Education Enhancement Project (DEEP)

Aims of the project

'Inkanyezi has raised my standards and my dignity' (Teacher, Eastern Cape)

*' DEEP is significant in that it will help shape our understanding of the challenges in rural education in South Africa in the context of poverty, inform the development of responsive strategies to the day to day realities of rural schools and communities and stimulate further research into the provision of quality rural education'. (*Makano Morojele, Nelson Mandela Foundation)

The Digital Education Enhancement Project is a research and development project, focussing upon two key 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 primary schools in Egypt and South Africa, with 48 teachers (two per school) and over 2000 pupils [i]. 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).

Using handheld computers for teacher professional development

The study of teachers' use of hand held computers reported in this paper is part of DEEP's wider investigation of the impact of new technologies on teachers' practices. This evaluation aims to assess the possibilities and constraints afforded by the handheld computers, as well as to examine how use of this new tool impacts upon teachers' professional practice. This aspect of the broader study focusses on the following questions:

- What are the benefits of using the hand held computer in a professional development context? What are the limitations?
- Does the use of the hand held computer change teachers' professional practices?

Contexts, schools, participants

DEEP was originally working with schools serving disadvantaged communities in two very different contexts: the city of Cairo, Egypt, and the mainly rural Eastern Cape Province, South Africa. All schools in the project serve disadvantaged groups- most of the Eastern Cape schools are situated in rural settings where project participants and their local communities have never experienced ICT. It is the experiences of these rural communities that are the particular focus of this paper.

Eastern Cape Province is one of the former homelands of South Africa, where poverty remains at its most severe [ii]. South Africa's population overall is 45.3 million, Eastern Cape Province's share is 6.4 million. South Africa's GDP per head of $2,500 - GDP per head in the Eastern Cape is $432. The range, type and intake of the project schools typify Eastern Cape demography: most serve largely remote and disadvantaged locations where unemployment is high, agricultural opportunities limited and resources scarce. These schools have negligible resources, apart from a small number of books and artefacts for basic numeracy and science work saved from recycled materials such as beakers, cardboard boxes, bottles and bottle tops. 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. Several 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 have been removed by members of the community to provide firewood during a cold winter or for building materials for makeshift housing.

Most of the teachers working in DEEP are female; IsiXhosa is their mother tongue. Their experience of ICT use was limited prior to the project and none had used a handheld computer. Most of the families in the rural communities served by the DEEP schools have never touched a computer / laptop / palm top, and most have never seen or heard about any of these technologies. For many pupils the pictures they took during the project with digital cameras were the first pictures of themselves or their environment they had ever seen. The brief case study that follows gives an introduction to the typical experience of teachers within the project.

Case Study

Xholisa and Elizabeth are experienced and committed teachers. Each day they travel to their school from the nearest town by local crowded taxi and then on foot (an hour's journey when the weather is good and the dirt road passable). For more than 12 years the extent of their professional toolkit has consisted largely of chalk board and chalk. They have access to a rudimentary library of books, most of which are in English (which is not the mother tongue of their pupils) and distant in content from their life experiences. The opportunities to update their subject knowledge for teaching or pedagogic practice have been as sparse as the teaching resources available to them.

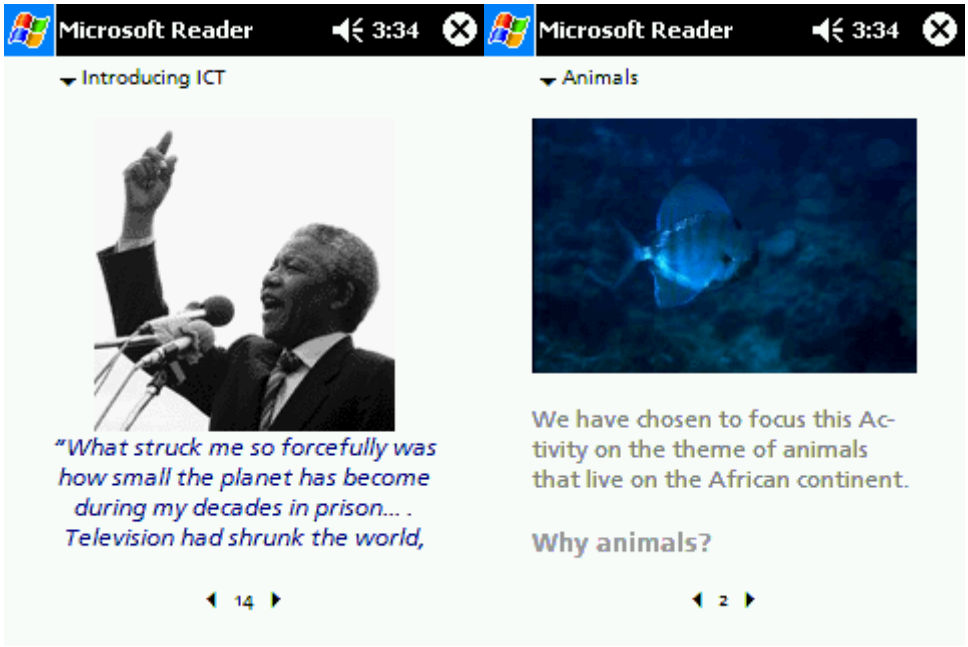
During the course of the DEEP project both teachers have been enthusiastic users of the hand held computer, using it everyday at home and at school. They use the diary and address book function for personal purposes; they also make considerable use of the device to plan their teaching. Elizabeth comments 'The [hand held] gives me information. It is very helpful for preparing lessons at home, because it's easier than writing by hand. I use it for getting and making resources and when I get to school I have used it in recording project information, making notes, recording students' language practice... I take pictures and get resources for my lessons... I use the calculator a lot' Xholisa encourages her pupils to use the hand held as a learning tool, and to store their work on it. The children use the notes,

memo, calculator and games functions frequently and the audio and voice recorder occasionally too. 'It is very educational to my learners'. 'The hand held', her project partner emphasises 'is my companion'.

The role of the hand held computer in DEEP

The DEEP project team has had two grants to support handheld specific research: the first from Hewlett Packard (in 2003) and the second from the NGO, bridges.org. (in 2004). These grants have enabled DEEP teacher participant (and project coordinators) to be provided with their own hand held computer and pocket camera, together with docking station and adaptor. In the early stages of the project these devices were viewed as an additional source of support for the teachers, given their minimal ICT experience and access. The more recent study has been focusing on the potential of the handhelds as professional tools.

All the project teachers were novice users of hand held computers. A range of professional development activities and other resources, created as illustrated e-books, have been installed on the handhelds. Teachers were shown how to locate and open these, as well as to bookmark pages, make notes and access multimedia assets (i.e. audio, video and flash animations) during brief training sessions.



The Trojan Mouse: existing research on the use of handheld computers in educational settings

Information and communications tools are becoming increasingly portable, flexible and powerful (Sharples, 2000) and numerous studies point to the potential of handheld technologies as learning tools (e.g. Fung, Hennessey and O'Shea, 1998; Hennessey, 2000; Soloway et al., 2001). Many studies have investigated the use of hand held computers in classroom settings but most focus on pupil learning (e.g. Fung et al.1998; Sestokas-Filho and Bonafini 2002; Yarnell 2003). A major systematic evaluation for SRI International (Vahey and Crawford, 2002) with over 100 teachers on the educational uses of hand held technologies in schools in the US suggests that teachers are highly positive about the use of hand held computers in the classroom. They are perceived as 'effective instructional tools', with the potential to have a positive effect on pupil learning. Key benefits are seen to be increased time using technology, increased motivation and increased collaboration and communication. Soloway (2002) argues that handhelds provide an opportunity for making major changes in educational settings. He dubs this mode of technology the 'Trojan Mouse'. His research team at the University of Michigan is developing a science curriculum for pupil use and complementary professional development material intended to embed technology into the everyday experiences of students and teachers via handheld technologies. Soloway et al. (2001) and Roschelle and Pea (2002), have all proposed ways in which hand held wireless internet learning devices in particular can offer physical affordances that are vastly different from school computer labs or classrooms with five students per computer. Such affordances (Gibson, 1979) they argue, may lead to learning activities that differ significantly from conventional images of school learning.

Waycott and Kukulska-Hulme (2000) investigated the use of handhelds to support adult learners studying on an Open University course. They report that the 'anytime, anywhere' access to learning resources is an important advantage of the handheld computer, enabling adult learners to fit study time around other activities. Pownell and Bailey (2000) outline six functions for 'educational leaders' that handheld computers can offer: Organizing and Planning; Reference Information (timely access to important information); Gathering and Analyzing (supports decision making through analysis of data); Learning and Self Improvement (supports life-long learning of current information and techniques); Communicating; Teaming and Collaborating (including sharing organizational documents, data bases and schedules).

The use of new technologies in developing country contexts

The advent of new information and communication technologies provides a new impetus to research the potential of computer technology in the countries of the Global South. Dhararajan (2001) points out 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' (p. 134). Pontefract (2001) has cautioned, however, that effective use of ICTs must be tied to the needs of developing countries and challenges the 'one size fits all' approach of many programmes. A study of computer costs and other issues in developing countries carried out for DFID by Cawthera (2001) concluded that 'the training of teachers in the use of ICT in schools is an important aspect of provision which may often be overlooked and under budgeted'.

He suggests 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'. Moon (2000),

Leach and Moon (2002), Dladla and Moon (2002) and Leach (2000) have pointed to the potential of communication technologies for transforming the models and processes of teacher development, as well as for enabling access to quality resources and professional support. Leach, Moon and Power (2002) suggest that ICT can offer teachers access to:

- scaffolding tools, that support teachers construction and understanding of new professional knowledge;
- environments and new contexts for learning, enabling teachers to experience new situations, practices and people;
- communicative tools, facilitating social participation structures between teachers and other educators (e.g. collaborative tasks);
- metacognitive tools, enabling teachers to reflect on the learning process, both at individual and group level (e.g. conferencing; joint products such as electronic self assessment).

Research (e.g. Vahey and Crawford op. cit.) suggests that hand held learning technologies overcome some of the major limitations of desktop computers, as well as providing new affordances for learning (Pea, 1993). Yet at the time of writing, extensive database searches have failed to locate research reports on the use of hand held technologies for teacher learning in sub Saharan Africa where teacher education is now so pressing. This paper suggests that these ideas need to be reviewed and evaluated, given the urgent capacity issues for teacher education in the Global South.

Methodology

Our first handheld study was carried out between January 2002 and May 2003, at various locations in and around Cairo and the Eastern Cape by the DEEP project team (local coordinators and researchers, together with OU researchers). Our task has been to try and capture the way in which DEEP teachers were using the hand held computers (if indeed they were) in their daily working lives. We judged that a mixture of quantitative and qualitative methodologies was the best way to do this; qualitative methodology in particular would allow us to gain a deeper insight, and greater level of understanding. Quantitative data collection methods have allowed us to triangulate our data, as well as allowing for individual responses.

Research tools

Over the lifetime of the project a wide range of data have been collected including: questionnaires (pre, interim and post project; project evaluations; hand held computer evaluation); semi-structured interviews (mid and end of project) with all teacher participants; one-to-one interviews with school principals; classroom observations (mid and end of project) in schools; feedback from pupils; electronic artefacts; laptop 'histories'; teacher and learner diaries; teacher and learner concept maps; a range of correspondence from teachers and pupils including letters, faxes, emails, message board postings; mobile text messages.

Findings

Using a hand held computer was a completely new experience for every DEEP teacher. The hand helds have proved popular in both contexts, although they are used far more extensively in the rural settings. Many of the teachers use them at least once a week or more, some on a daily basis. Only one (of forty-eight) said the device is 'not useful'. A significant number use the hand helds in the classroom and many pupils were observed using the devices during classroom visits. The functions utilized as well as the purposes and constraints of use - differ in the country settings.

The Eastern Cape experience

The hand held is highly popular in the Eastern Cape. Every teacher uses it at least once a week or more, several using it on a daily basis. The majority uses the device both at home and in the classroom; 5 teachers state that they use the device whilst travelling. The majority of the teachers report that the hand held has 'helped their ICT skills' and 'understanding of the language and concepts of ICT'. Overall the device is seen as 'very useful' and viewed as of 'equal value' as other computers, '[I] can do anything I may do with the other computer'. This is in a context where 56% of teachers and 75% of the school communities have had no prior experience of any form of computer technology (i.e. both hand-held and shared laptop PC were being used for the first time). The handhelds are so popular that more than half of the teachers would be willing to buy one with their own funds (if the price was affordable).

Limitations

When the hand held was regularly recharged, or backed up to a computer, data was retained without problem. However, in both countries there were occasions where teachers suffered data loss due to a loss of battery power, where the data had not been synchronised with another machine. These instances were far more apparent in the rural South African context than the urban Egyptian context however. In the Eastern Cape, half of the project schools have no electricity supply and in many schools that have electricity it is not available in every classroom. At one remote rural school teachers N____ and L_____ live almost entirely without electricity in the settlement surrounding the school. To recharge their project equipment the teachers walk a few miles down the unmade track to the local hospital. Many of the Eastern Cape teachers had used their hand held computers extensively, so those who discovered their lost data was irretrievable were particularly grieved; one teacher in a school without electricity reported being extremely upset when their data was lost. Appendix A sets out some of the technical issues in more detail – some of which have been raised by our most recent handheld study.

Discussion of findings from the first study

Has use of the hand held computer changed the teaching task and teachers' professional capabilities? In this section we identify a number of key areas of change.

Anytime, anywhere learning

Size and weight was viewed as being a very important aspect of the hand held (particularly in the Eastern Cape context) and this was usually linked to the sense of its portability. This view surfaced strongly in the qualitative data. 'It is useful because you can carry it everywhere you need it'. 'Since the Jornada is always in my bag it is easy to reach'. '[The] Jornada is user friendly because it is not too heavy'. The majority thought the weight and size 'just right'. It should be noted that in both contexts security is of major concern. Handhelds are easily concealed, deftly popped into pockets or handbags at the end of lessons and are not conspicuous when travelling. Teachers reported feeling safe when carrying this 'invisible' device, where they felt more conspicuous and vulnerable carrying a laptop bag. Teachers reported on the expansion of their capabilities as they used and got used to the hand held computer (Salamon and Perkins 1997); many consider that there is something quite new and unique about the opportunities provided by such a flexible device in their particular context. It has offered possibilities in terms of access to 'anytime, anywhere' professional activity. It can be used at home, in the classroom, in friends' homes, on fieldtrips or at a special event. It can be taken from classroom to classroom and within classrooms be handed from pupil to pupil, thus enabling it to be integrated with ease into the flow of daily activity, including in some instances, fieldwork outside the classroom. In this sense it is the computer that moves with the learner as directed by the teacher, to serve particular pedagogic tasks. It has not disrupted the normal layout of the classroom or required special furnishing.

New tools enable new learning activities

The diary, calculator, camera and games are the most popular functions and these are used both at home and in school. Every teacher mentioned taking photographs when describing its use; 5 made use of the voice recorder 'frequently' ('Using the instrument in taking photos and in recording information'). Word is well used by a significant number of teachers, particularly for lesson preparation. Half of the teachers have used the hand held to access the DEEP professional development resources; 11 have made use of the multi-media resources.

Enhanced professionalism

"...I don't think I can teach without [ICT] again (laughs)! ... can't go back and teach differently in the future..." (Teacher participant interview, 2003)
What of the more lasting effects of the handhelds, beyond discrete occasions of use – the impact on teachers' 'cognitive arsenal of skills, perspectives, and ways of representing the world' (Salomon, Perkins, & Globerson, 1991)?

Organizing and Planning

'*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! ... it's now that I can feel myself as a professional. Warm greetings. Bye'*
(E-Mail from DEEP Participant, 2002)

In rural and resource challenged contexts where teachers have hitherto had to rely solely on notebook, chalk and chalk-board as their only means of planning and storing information 3, the hand held has modified the way teachers organize, think about, and indeed carry out aspects of their work, as well as the way in which they work with others. Highly suited to organizational tasks, data collection and planning is much easier to carry out. It is ready to hand, when any one of a range of applications are required. Project teachers were observed using the hand held for professional purposes such as preparing lessons and making notes on pupil progress. They reported using it to: record appointments; take pictures of students; summarize some lessons; note take during lessons; take photographs for curriculum use; make calculations; set reminders for tasks; record events (e.g. Mark Shuttleworth lecture) to use as the focus of a lesson; record and photograph pupil work, presentations and music to show parents; teach peers basic ICT skills and concepts (i.e. terminology, handling the stylus, moving between programs'). The hand held has enabled effective organisation, including re-use and storing of resources.

Collaboration and shared professional learning

The use of the hand held facilitates new forms of collaboration between project partners and local cluster groups. Teachers use infrared 'beaming' to exchange resources. In the cluster sessions researchers attended, teachers were observed sharing lesson plans, photographs, recordings and presentations that they or their pupils had made. These impromptu 'show and share' sessions were times of intense interest - and laughter. This form of collaboration - shared learning and practice is difficult to achieve when teachers have no means of storing, adapting and amending their work. One of the project teachers described a sense of real frustration that, prior to the project, her main professional tool was the chalkboard. Material she wanted to present or discuss with pupils had to be laboriously written by hand on the board, often with a stub of chalk, and removed at the end of the day: in this sense, curriculum work was highly constrained and transient. Every day, lesson content had to be approached from scratch. Resources of the type most teachers in the Global North take for granted simply cannot be created. The ability to store and then share ideas, plans and resources at a later date was also a major breakthrough in project teachers experiences. When teachers from several schools exchanged materials at cluster meetings there was a sense of real excitement. The project team was also able to transfer new professional resources to the hand helds at training sessions. Such activity encouraged shared learning and the possibility for professional updating.

New Classroom practices

Pupils in the Eastern Cape were observed using the handhelds for a wide variety of activities including: literacy activities; peer tutoring; mathematical games; group work; photography; field work; language practice (recording and listening to conversation). The researchers accompanied pupils from two of the project schools on a fieldtrip focusing on the use of solar power. Pupils were observed sharing the handheld to take photos, record interviews and make notes. They were fluent users of the device. 'They are really curious to learn now. They ... most of them have changed their attitude. Yeah ... I will always have those who don't want to answer, but most of our learners have changed. We are continuing with our research on solar energy ... when I was talking to them, I said 'For this project we need to work hard.... go to the villages that are using solar energy and to find out the effect' ... You can come up with some idea and then we'll go and visit one of these areas.... use our [hand held], come back to school... and then we prepare our reports about, research about solar power'. So I mean I can see, when I said 'Use our [hand held]'. Like I could see light! They are ... really looking forward now to going and doing this research.'(Teacher interview, 2003) A_____ noted changes in her approach to teaching.

Dignity and self-esteem

Many project teachers have provided testimony to the way in which their self esteem and professionalism has been raised by the use of the handheld computer, together with the adjacent technologies within the DEEP project. Ownership of the handhelds marks a change in status and professional competence. Many teachers in the Eastern Cape used the personal pronouns 'my Jornada' or even 'my companion' when talking about the device. Several mentioned 'we use it everywhere'. There was a strong sense of ownership; the device was not alien, appearing to be fully appropriated into daily practices. Elizabeth referred to this development of professional identity during a recent interview: 'I have changed. It has made me proud because I now know how to use ICT. At first I didn't know anything ... it has changed us really. Xholisa echoes this sentiment: '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.'

This sense of professional affirmation was not limited to project teachers alone, but extended to colleagues and parents: 'Great excitement from parents and teachers ... so there has been great enthusiasm' [School principal interview, 2002]. 'The view is that they are no longer in the shadow of the 'model school' in their town or city. There are a lot of computers in the model schools. It's appropriate technology ... Even other parents now want their children to come to our school' (Interview, 2003).

Conclusion: 4D technologies for teacher education

Our small-scale studies indicate that hand held technologies may have a significant role to play in transforming the opportunities for teacher education in developing contexts. Teachers and schools in challenging environments might benefit from the many advantages that ICT is currently affording richer peers, whilst leap-frogging expensive mistakes made by more affluent countries. We have cited influential studies based in North America that demonstrate the benefits of 'anytime, anywhere' learning technologies for education and learning. (e.g. Vahey and Crawford, op. cit.), where serried ranks of unwieldy, fixed computers in school computer labs are being replaced by more user friendly, flexible technologies (e.g. Cooper 2002, Soloway 2002), used at different sites of learning, both in and out of school. A range of new educational softwares are being developed for hand helds and compelling usage scenarios being identified. Hand held devices have, to date, been largely aimed at the business market and needs of high-powered executives. Teachers in the DEEP study have been able to appropriate these devices for their own professional and curriculum purposes. Teachers have also reported that the hand held computers had positive effects on student learning, encouraging an ongoing, integrated use of technology within the flow of classroom activity. Many schools commented on the improved grades and outcomes of pupils in classes using the ICT, particularly in literacy. They also reported on increased pupil motivation and in some cases increased pupil attendance. This reporting by teachers, governors and school principals needs testing more systematically over time. However, the ease of integration of the hand helds into classrooms and its support of new classroom practices such as paired and group work is continuing to be observed by the research team, suggesting that powerful computing can become integral to learning. As a result of these observations, the research team has begun to re-conceptualise these new tools for learning: we call them 4D Technologies.

4D technologies for teacher development, like the multimedia handheld and laptop computers used in DEEP, are technologies that can support and enhance:

- **Development**
- **Democracy**
- **Deep learning**
- **Dignity**

Development, in the sense of the personal and professional development of teachers and their pupils, but also in the sense of supporting the achievement of the Millennium Development Goals. The entitlement to Universal Primary Education means not just getting children *into* schools, but raising the quality of education that occurs within rural schools. 4D technologies may have an important role in this. Appropriately deployed, they may also begin to redress gender disparities and other traditional inequalities (for example, three quarters of the DEEP teachers were women, working with young children, in disadvantaged rural communities). 4D technologies are also 'developmental' in a technological sense, incorporating emerging technologies (like the handheld) and networks (like the mobile phone network) in the service of these communities.

Democracy, in the sense that deployment of ICTs into the hands of those who need them most (see above) can challenge existing inequalities – where ICTs are predominantly in the hands of the wealthy, urban, white, male professionals. We would argue that one computer in a rural school can have far more impact on learning than one computer in an affluent and well resourced school.

DEEP learning, where pupils are not learning facts dissociated from their own experience and culture, but are able to access and understand information that is part of the global

corpus of knowledge, and also to capture and reflect upon aspects of their own environment and culture. 4D technologies allow teachers and learners to weave these two domains together participating in a new discourse within their classrooms, and with the wider world.

Dignity. The teachers on the DEEP project have often spoken about a change in their self-perception, and the way they are perceived by others in their community, which has become an organizing concept: dignity. Teachers have shown amazing commitment to their profession and their pupils, often in the most challenging circumstances. The opportunity to use professional tools in their work has raised their perception of their own professionalism, but also the esteem of teaching, and perhaps more importantly, of the school as a whole, in the eyes of the community. "It is now I feel myself as a professional" (DEEP teacher).

Further questions arose as a result of the original study, which are now being explored in a second phase:

- In what ways can hand-held tools best complement other resources, including traditional technologies, in the context of school based teacher development?
- What curriculum related developments do hand held tools best enable? What software innovations are required?
- What are the specific learning affordances offered by hand-held computers in the context of respect of teacher development, less viable by other means?
- Can hand held computers support the task of school principals and educational leaders?

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[i] In Phase 2 the project reach is being be upscaled to 72 schools and new countries (e.g. Tanzania and Bangladesh and the Sudan) 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)

[ii] Data shows that the provincial share of the poverty gap [i.e. the combined measure of numbers in poverty and their depth below the poverty line] nationally is greatest by far in Eastern Cape. The comparative provincial data is: Gauteng 4%, Northern Province 16.5%, Kwa Zulu Natal 19.9%, Western Cape 3.4%, Northern Cape 1.9%, Free State 9.9%, Eastern Cape 24.9%

Appendix A Technical Report

Background – DEEP 2001-3
The DEEP project developed resources specifically for use on the HP Jornada 565 Pocket PC device running the Pocket PC 2002 version of the Windows-based Operating System. These resources were adapted from original print and web material into Microsoft Reader format for use on the Pocket PC. Later developments included versioning web pages for use locally on the devices, incorporating Flash and Multimedia elements. Use of a separate Jornada Cam CF interface device was also encouraged. Addition of resources and required applications involved installation onto each individual device, or for researchers to 'beam' resources/files to one another.

Technical issues raised as a result of teachers' evaluation of using the Pocket PCs, particularly in South Africa during the period of DEEP research were as follows:

- Synchronization problems – faulty interface at base of unit
- Battery issues – lack of charge stations due to fragile electricity supplies in some schools; lithium backup batteries discharging as a result and needing replacement
- Memory and backup problems – memory requiring battery backup even when device inactive. Loss of battery resulting in total data loss and loss of installed applications.

Development and reversioning for DEEP-ER and iPAQ H4150

Preparation Issues
Initial investigations showed that Microsoft had revised the Pocket PC platform to be more standards compliant. The iPAQ H4150 runs the Pocket PC 2003 Windows Mobile operating system. All applications required for the current project needed to have updated versions installed, this has affected previous web page resources the most. Windows Media 9 appears not to have an ActiveX component (provided separately in the previous Series 8 version). This meant that despite lengthy testing and development to include XML tags and JavaScript functions, audiovisual content can no longer be embedded within web pages and needs to be provided as hyperlinked, but standalone files.

In order to provide the devices with a larger capacity- and to attempt to centralise resource provision, the project team decided to provide project content on SD Memory Cards, which might also be used as transferable personal storage for use with shared digital cameras and DEEP-ER research outputs.

Installation of additional applications requires individual synchronisation with each device, setup as a 'Guest' device with Microsoft ActiveSync. Improved batch processing of application installers was investigated, but ActiveSync itself was found to have been improved to allow a quicker method of installation onto numerous Guest devices.

Testing
The battery maintenance issues identified in previous research are improved on the iPAQs, but still not ideal. Both main and backup batteries are rechargeable, however on-board memory still requires battery backup to maintain data. Total battery loss can be largely equated to a 'hard-reset' of the system, so this also informed the investigations.

Given larger capacity for both on-board memory and the additional memory card, alternative fail-safe methods of storage were investigated:

- Safe store (using on-board ROM to maintain data) – available capacity very limited, but applications would always be available irrespective of additional memory.
- Storage card (within a specific folder on the external card) – large capacity available, but applications unavailable if removed e.g. for other SD interface usage.

Both destinations are supported by ActiveSync as locations in which additional applications can be installed, however they are not the 'default location', which is important to some applications. Of the additional applications provided by the project, the Flash plugin and the Keyboard driver were sufficiently small to be installed into Safe Store, and this seemed most appropriate. Unfortunately, however, the Keyboard Driver requires installation into the 'default location' in the main on-board RAM, and is not therefore protectable from battery loss nor hard reset.

Ultimately, investigations into changing the location of installed applications have proved unfruitful, as even if the applications were securely stored, the shortcuts to those applications from the 'Start' and 'Programs' menus would be removed on battery loss. The decision was then taken to install all applications into the default location in the main on-board memory, with all centrally provided resources provided on the Storage card, allowing use of remaining on-board memory for working files.

A further concern was the choice of media format for the professional development resources. Previous experience of creating Microsoft Reader files was that the file format was highly problematic in its rendering of embedded objects such as tables, charts and images. Subsequent investigations also included use of Adobe Reader and Palm Reader, with summarized findings below:

Microsoft Reader – default, stable and packaged application (not deleted on battery loss/hard reset), problematic creation process, limited embedding. Annotations possible

Adobe Reader – reasonably faithful reproduction of PDF files, allowing for comments to be read. No annotation provision. Application occasionally prone to crashing, requiring soft reset.

Palm Reader – good creation and rendering of embedded objects; annotation and highlighting provided. Application itself prone to faulty menu generation, requiring soft reset to remedy.

As a result, resources were initially provided in all 3 formats, playing to individual application strengths. Legacy content remained in Microsoft Reader format, while largely image-based resources were provided in Adobe Reader format and resources requiring a large degree of interaction were provided in Palm Reader format. An intention to investigate eBook creation using the more user-friendly eBook Studio was logged for future consideration.

Installation of resources and applications

Resources were developed for use on all 24 handheld iPAQ H4150 Pocket PCs. A master folder of content was assembled, to be copied to the SD Memory Cards - comprising all reader files, web pages, audiovisual assets and texts. Palm Reader in particular required files to be in a specific folder to be discovered by the application – they would not be run via the File Explorer provided as part of the Pocket PC 2003 Windows Mobile platform (no filetype association).

Despite providing correct filetypes, suitable folder hierarchy and application setup, installation proved to be non-trivial in that professional versions of some software required individual registration, individual eBooks required authentication and at one point in the file copying process, a filetype was corrupted so it could not be read without renaming.

These latter issues will of course resurface when a device suffers total data loss, as the location of the storage of such user information is unclear.

Training for teacher users

To support teachers in the familiarisation and orientation in using the new devices, a dedicated iPAQ skills session was provided. A wireless projection device was used to enable all participants to see the progress and visualise the procedures needed to run applications and explore the resources. This session covered the principles of the menu system, the program and settings screens and the file explorer navigation, for those unfamiliar with Windows. The remainder of the training sessions focused primarily on professional activities, using the resources provided. Technical information was introduced on a need to know basis with respect to navigation, annotation, highlighting, and related use of the Pocket Office (Word, Excel) applications. In this way, new technical knowledge was introduced in tandem with professional activity- strongly led by professional purposes. This approach was deliberate, and built on the findings of DEEP that technical expertise can be quickly developed where professional purposes are strong and motivation therefore high.

Teacher feedback

Once users were operating the devices themselves, another major issue quickly emerged i.e. the instability of reader software requiring frequent soft-resets. Teachers welcomed the ability to charge the iPAQ while docked in the keyboard (not available on the Jornada), though only having a mains socket charger proved a drawback.
Some of the experienced handheld users consider the iPAQ less robust than the Jornada they were previously using because of the latter's screen cover.

Technical Recommendations

- Provision of on-board Flash-RAM as standard, with a secured area if required, rather than RAM/ROM hybrid.
- Keyboard driver should be provided as standard, so as not to be lost on battery fail/hard reset
- Syncing interface (PCB edge connector) should be more robust – both data and battery charging could be lost at same time
- Charging/synchronization lead should be powered-USB compatible as standard, including USB charger unit for mains charging.
- Alternative syncing methods could be provided – Bluetooth/WiFi