Deep impact:
a study of the use of hand held computers
for teacher professional development
in primary schools in the Global South

Fig 1. Peer teaching, Eastern Cape, South Africa.

Web site: http://www.open.ac.uk/DEEP
Acknowledgements

We would like to acknowledge the work of all the schools that have participated in this research - particularly the students and project teachers.

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"Go on!...... you know what to do..."

The paper is one of a series dedicated to the memory of Adi Kwelemtini, DEEP project Co-ordinator, South Africa 2001-2002

January 2004
Abstract

The Digital Education Enhancement Project (DEEP: http://www.open.ac.uk/deep) is investigating the ways in which new technologies can improve the teaching of literacy, numeracy and science in primary schools in Egypt and South Africa. 48 primary teachers (24 in each country) have been carrying out a sequence of classroom-focused professional development activities, using a range of new technologies. Each teacher has been provided with a hand held computer and pocket camera for use throughout the project. This study reports on the use made of these devices by teachers and students across a twelve-month period. The data drawn on includes pre and post project questionnaires, teacher interviews, together with observations of teachers and students using the hand held computers. The findings of the study indicate that use of the hand held computers has:

- Enhanced teacher professional capability by:
  - widening opportunities for professional planning;
  - extending their range of pedagogic practices and subject knowledge;
  - permitting new forms of teacher-to-teacher cooperation.

- Improved teacher professional development in relation to:
  - the way students view their teachers;
  - the way local communities perceive the school;
  - teachers’ aspirations for future personal development.

- Varied in relation to context, particularly with respect to:
- teacher access to adjacent technologies;
- geographical location;
- local educational and cultural practices;
- home language.

The study suggests that future research and development should exploit the potential for improvement and the conditions in which such outcomes can be realised, and further investigate the potential of state of the art technologies for contributing to teacher education in developing contexts.
Introduction

"[There are]... several regions far from achieving universal primary education and, in the case of sub-Saharan Africa, actually lagging behind...
The less developed regions as a whole account for 97 per cent of the 113 million children not in school."

(OECD, 2000)

In poor communities the scarcity of trained local personnel (e.g. teachers [...] and the impediments they face in accessing vital information and enhancing their skills, perpetuates the low educational attainment [...] of these communities......

(DFID 2002 p.7)

Hi

Things are changing bit by bit. Our technology skills are being developed. No one can 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.

(e-mail from DEEP teacher participant, 2002)
113 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 bricks and mortar 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 (Moon, 2000; Leach and Moon, 2002; Dladla and Moon, 2002). 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

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 student 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.

DEEP is working in 12 primary schools in Egypt and 12 in South Africa, and with 48 teachers (two per school). Since January 2002 the teachers have been implementing and evaluating a sequence of curriculum focused, school based professional development activities using a range of new technologies, including hand held computers 1.

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1 In addition to hand held computers, project teachers in the Eastern Cape share one laptop and one multi-purpose printer / scanner / copier; project teachers in Egypt use the school’s multi media lab and in addition have a multi purpose project printer.
DEEP is funded by the U.K. Department for International Development (DFID) and coordinated by the Open University (UK), with the University of Fort Hare (UFH), South Africa and the Programme, Planning and Monitoring Unit (PPMU) Egypt.

*Using hand held 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 (Leach et al, 2002; Leach, 2003). This evaluation aims to assess the possibilities and constraints afforded by the hand held computers used in the project, as well as to examine how use of this new tool impacts upon teachers’ professional practice. This aspect of the broader study focuses on the following questions:

1. What are the benefits of using the hand held computer in a professional development context?

2. What are the limitations?

3. Does the use of the hand held computer change teachers’ professional practices?

*Contexts, schools, participants*

DEEP is 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.

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Fig 2. Cairo, Egypt.

Cairo, Al Qahirah, is the largest city in the Middle East and in Africa, with a population of nearly 17.8 million. Egypt as a whole has a population of over 73.0 million; GDP per head is $951. It is a relatively ICT-poor country; in 2001 there were only 15.5 computers per 1000 of the population, 600,000 internet users and only 146.9 fixed line and mobile telephones per 1000 of the population.

The twelve project schools are scattered across this sprawling, diverse city, in a wide range of locations such as El Sharabia in the north (with the second highest population density in the city) and Bab-El Sharia in the most ancient part of Cairo.

Each project school has one small multimedia lab, funded and specified to a common format by the Ministry of Education, with minimum of one

3 Source: World Development Indicators database, last update April 2001

2001 Data for comparison:
UK: population 60.5m; GDP per head $31,860; 366.2 computers per 1000 of population; 19,800,000 internet users
Germany: population 82.5m; GDP per head $30,810; 434 computers per 1000 of population; 30,800,000 internet users
computer (with CD-ROM drive and internet connection) linked to an overhead projector and printer.

The majority of the project teachers in Cairo are in the 20-30-age range; just over half are women. Arabic is their mother tongue. Prior to the project, 22 of the teachers had some experience of using computers, but of these, only 3 had used computers ‘a lot’ and only half had used them (‘a little’) in teaching.

Context 2:

Fig 3. The Eastern Cape, South Africa.

Situated at the opposite end of the continent, the Eastern Cape Province is one of South Africa's former homelands. The poverty gap in this province is greater than anywhere else in South Africa. South Africa as a whole has a population of 46.4 million and a GDP per head of $3,310. In 2001 there

4 2001 Data for comparison:
Spain: Population 41.1m; GDP per head $22,690; 168.2 computers per 1000 of population; 7,388,000 internet users
France: Population 60.4m; GDP per head $31.640; 328.6 computers per 1000 of population; 15,653,000 internet users
were 68.5 computers and 364.3 fixed line and mobile telephones for every 1000 of the population, and 3.1 million Internet users, across South Africa as a whole. However, most of these resources are concentrated in urban areas.

The range, type and intake of project schools in the Eastern Cape typify the region as a whole. Three are located in towns and have some resources. The rest serve remote and disadvantaged rural locations where unemployment is high, agricultural opportunities limited and resources scarce. Six of the schools have no electricity and five no telephone connectivity and can only be reached by several hours’ drive on dirt tracks.

Two thirds of the project teachers are in the 40-49 year old age range; over half are female. IsiXhosa is the mother tongue of most teachers. None of the teachers owned a computer and 14 had never used one prior to the project. The majority (18) had never used the Internet. Of the 10 teachers who had used computers, 5 had ‘occasionally’ used them in relation to teaching. The other 5 had used computers at Internet or study centres, or with friends, but never for teaching.

Most people in the rural communities served by the schools have never touched a computer / laptop / palm top, and most have never seen or heard about any of these technologies. For many students the pictures they took during the project with digital cameras were the first images of themselves or their environment they had ever seen. The brief case study
that follows provides an introduction to the typical experience of teachers within the project.

Case Study

Fig 4 “The hand held computer is my companion.” Primary school teacher interview, Eastern Cape

Rachel (Imimoya School) is an experienced and committed teacher working in the Eastern Cape. Each day she travels to her 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 her professional toolkit has consisted largely of chalkboard and chalk. She has a rudimentary library of outdated and worn books in her classroom, most of which are in English (not the mother tongue of her students and remote in content from their life experiences). Opportunities to update her subject knowledge for

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5 The names of teachers and schools have been changed
teaching or pedagogic practice have been as sparse as the teaching resources available to her.

Since the outset of the DEEP project she has been an enthusiastic user of the hand held computer, using it everyday at home and at school. She uses the diary and address book function for personal purposes; she also makes considerable use of the device to plan her lessons.

"[The hand held] gives me information. It is very helpful for preparing lessons at home, because it is 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.’

Rachel encourages her students to use the hand held as a learning tool, and to store their work on it. They use the notes, memo, calculator and games functions ‘frequently’ and the voice recorder occasionally too.

"It is very educational to my learners”. The hand held, she emphasises "is my companion”.

The role of the hand held computer in the project
In January, 2001, during the project’s scoping phase, the DEEP project team observed with keen interest the widespread use of cell phones in the rural areas of the Eastern Cape - and how important this mode of technology was to those living in isolated settings. Some teachers told us they walked many miles each week to the nearest source of electricity in
order to charge their mobiles. This experience encouraged the team to think about trying to explore the potential of hand held computers to support teacher learning within the project.

It was not until late spring 2002 just as the project was getting underway, that two small grants were finally secured from the Open University and Hewlett Packard, enabling every teacher participant (and both project coordinators) to be given their own state of the art hand held computer and pocket camera, together with docking station and adaptor. For this reason the devices were introduced to the teachers simply as an additional source of support to develop their confidence and skills, given their minimal ICT experience and personal access.

In a brief (half day) workshop session, teachers were shown how to enjoy the devices including: basic applications (e.g. Word, calculator, games, on-screen keyboard); use of the camera; how the infrared beam facility could enable document sharing; and how the device could be synchronised with the shared laptop (South Africa) or school PC (Egypt). The team installed the DEEP professional development activities on the hand holds in the form of illustrated e-books, together with a range of other resources (e.g. case studies, exemplar lesson plans etc). Teachers were shown how to locate and open these, as well as how to bookmark and annotate pages, make new notes and access the related multimedia assets (e.g. audio of Martin Luther King, video clips of classroom practice; flash animation of a well-known fable).

6 Hewlett Packard Jornada 560 (Colour 32MB, with 206 MHz processor)
The Trojan Mouse: existing research on the use of hand held 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 hand held 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 student 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 student learning. Key benefits are seen to be increased time using
technology, increased motivation and increased collaboration and communication.

Soloway (2002) argues that hand helds 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 student use and complementary professional development material intended to embed technology into the everyday experiences of students and teachers via hand held 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 hand helds 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 hand held computer, enabling adult learners to fit study time around other activities. Pownell and Bailey (2000) outline six functions for 'educational leaders' that hand held 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 in developing countries 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**

The study was carried out between January 2002 and May 2003, at various locations in and around Cairo and the Eastern Cape by the DEEP
Smith (1988: 19) argues that ‘an important aim of inquiry must be to capture something of the meaning of life in particular social settings’. 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.

**Sampling Procedure**

Schools were selectively sampled against criteria jointly drawn up by the local coordinators in both countries:

- ‘The school principal must endorse the project and be clear how it will benefit the school;
- The school must nominate two teachers willing to work together
- These teacher partners must be:
  - Motivated and dedicated to teaching and learning;
  - Interested in introducing classes to new ideas;
  - Enthusiastic about new teaching methods;
  - Keen to find out how computers can help learners;
- Willing to undertake basic computer training and invest up to 30 hours of time over a one year period to the project (some of this time in the classroom).\textsuperscript{7}

The project schools and teachers in Egypt were chosen jointly by the PPMU and Ministry of Education. Schools in the Eastern Cape were shortlisted by a UFH panel from 91 expressions of interest generated by a local radio programme. Both groups ensured that the schools selected were representative of a range of locations and type (e.g. in Eastern Cape peri-urban/rural/ with/ without electricity/ phone etc.).

The core of the DEEP project is the use of ICT in classrooms and community settings by teachers who are interested in developing teaching. This study relies to a large degree on their reported experiences of using the hand held computers, together with observational evidence during workshops and classroom visits. As a group of teachers committed to new approaches to teaching, they are certainly not representative of all teachers in Egypt and South Africa. They are however, in other ways, a highly diverse group in terms of: the settings in which they live and work, the subjects they teach, their experiences and teaching styles, as well as in their prior ICT experiences. This diversity constitutes a strength of the evaluation data. We argue that it gives a more rounded view of the performance and usefulness of the hand helds than if we had looked at their use by a more homogeneous group.

\textsuperscript{7} DEEP project Scoping Paper, March 2001; no incentives other than training, nor any promise of ICT equipment, were offered.
**Research tools**

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

This study draws on this data, but specifically:

- End of project questionnaire focusing hand helds (33 responses. 23 of 24 teachers Cairo; 10 of 22 teachers SA);
- End of project interviews with 38 teachers (20 in Cairo; 18 in SA)
- End of project observations in 19 schools (10 in Cairo; 9 in SA)

**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. The

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8 1 school of the 24 schools was asked to withdraw from the project in mid 2002 after consistently failing to attend workshops and cluster meetings. The lower return for SA is accounted for by the fact that questionnaires were completed on school visits to isolated locations: collection of teacher and pupil outcomes, observations, teacher interviews, exit questionnaires took precedence if there was insufficient time.
majority (29:88%) of the 33 respondents to the questionnaire report that they use the devices on a regular basis:

- 7 (21%) ‘once a week’;
- 16 (48%) ‘a few days a week’
- 6 (18%) ‘daily’.

Only one of the teachers said the device is ‘not useful’.

**Size and weight**

Size and weight was viewed as 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’.

**Functionality and use**

The diary, calculator, camera and games overall were the most popular functions, used both at home and in school. Every teacher mentioned taking photographs when describing use of the device. 17 (51%) of the teachers reported using the hand held to access the DEEP professional development materials. 11 (33%) made use of the multi-media resources. In interviews project teachers reported using the devices for a range of activities including to: prepare lessons; make notes on student progress; 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 to use as the focus of a lesson; record and photograph student work, record presentations and music to show parents; teach peers basic ICT skills and concepts (i.e. ‘terminology, handling the stylus, moving between programs’) (Teacher questionnaires). Project teachers were observed using the hand held for many of these professional purposes.

Some functions utilized – as well as the purposes and constraints of use - differ in the country settings and these are set out in the country specific sections below.

**Classroom use: an unexpected outcome**

Although some teachers did not consider the device suitable for using with students ‘its limitation is it being small and unable to show it to the learners’ (Teacher questionnaire), during interviews a surprisingly high number reported using the hand helds with students in the classroom. Researchers also observed classroom use in 10 of the 20 schools visited at project end. Since the researchers had not expected the hand held to be used in the classroom, this purpose had not been specifically addressed in the questionnaire.

**The Cairo experience**

Overall the hand held was seen as ‘somewhat’ or ‘very useful’ (21: 91%) by the Egyptian teachers in their response to the questionnaire. Specific benefits recorded included: ‘the enjoyment in using state of the art instuments’; ‘fun’; ‘research and knowledge’; ‘learning some English
language (Teacher questionnaire). Over half of the respondents considered that the hand held ‘helped their ICT skills’. The majority thought it helped their ‘understanding of the language and concepts of ICT’. 4 of the teachers thought that it was ‘of more value’ than other computers they had used.

These findings were confirmed in end of project interviews. Home use was the most common, *‘using it was very helpful to facilitate preparing for lessons at home because it is easier than writing by hand’*, (Teacher interview). The researchers observed the hand helds being used by students in 5 of the 11 schools visited, for a variety of activities including: note-making, group work and photography. In one lesson focusing on ‘our local environment’, students were observed taking turns to work in small groups outside the school, using the hand held to make notes and take pictures.

**Limitations**

Arabic is the principal language of Egypt. All of the teachers have some knowledge of English, but their competency varies. Fluency in English was not a requirement of the project, nor is it common amongst primary school teachers in Egypt (most of the DEEP resources are available in Arabic). The Cairo teachers were promised an Arabic version of the Operating System (OS), in this case Windows for pocket PC at the outset if the project. At the time of writing this has still not been made available, though there is some possibility that the project teachers may become ‘beta-testers’ for an Arabic version of the OS in 2004.
Our research findings suggest that the lack of support for Arabic has proved a major disincentive for the teachers in Cairo to make full use of the hand helds in their writing practices. All the Cairo teachers mentioned in questionnaire - or at interview - that the language issue constrained their use of the device. The functions most frequently used for personal purposes in Cairo have been those that are the least language dependent, for instance the calculator and games – and of course the camera.

Teacher Mona, for example, reported in her questionnaire ‘being not proficient in English Language makes me find difficulty in using the Jornada’. She also notes however: ‘Every advanced scientific device has a use for an increase in knowledge’ and ‘the Jornada is very useful in making pictures’. She reports that she uses the camera ‘where students produce class-related pictures’ (literal translations from Arabic by Egyptian colleague). In a visit to Mona’s school in Al-Khalifa, southern Cairo, an area of severe poverty, researchers observed her students using the hand held fluently for photography– but also for note making.

**The Eastern Cape experience**
The hand held is highly popular in the Eastern Cape and used for a broader range of activity than in Cairo. All respondents said they used the device both at home and in the classroom. 5 stated that they use the device whilst travelling. The majority reported that the hand held has ‘helped their ICT skills’ and ‘understanding of the language and concepts of ICT’. These findings were confirmed by end of project interviews.
Overall the device is seen as ‘very useful’ (9: 90%); 7 viewed it as being of ‘equal’ or ‘more 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 hand holds 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.

Uses of the device were wide-ranging and creative. Word was well used by a significant number of teachers, particularly for lesson preparation. 5 teachers had made use of the voice recorder for curriculum purposes ‘frequently’. Other uses mentioned included: ‘I used Word for writing and I left the device to the students’; ‘I used the camera many times to take photos related to the lesson I’m teaching and also to write some information’; ‘during the monthly exam’; ‘writing and recording appointments’; ‘listening to songs and watching song clips’; ‘making various slides on some animal and it's various characteristics’. (Teacher Questionnaire)

‘We have used the Jornada for sports days for cultural days, for all the activities.....in the classroom situation, we’ve taken pictures of our learners. (Teacher interview, 2003)

Hand holds were observed being used by students in 5 of the 9 schools visited for a variety of activities including: photography, literacy activities, research, language / conversational practice, mathematical games.
Limitations

When the hand holds were 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 Winnie and Beverly live almost entirely without electricity in the settlement surrounding the school9. To recharge their project equipment the teachers walk a few miles down the unmade track to the local hospital. Since any of the Eastern Cape teachers had used their hand held computers extensively to store resources, those who discovered this data was lost irretrievable were particularly grieved; one teacher in a school without electricity reported being ‘extremely upset’ when their data was lost.

Security issues

In both contexts security is of major concern. Hand holds are easily concealed, deftly popped into pockets or handbags at the end of lessons and are not conspicuous when travelling. Teachers in rural locations reported feeling safe when carrying this ‘invisible’ device, where they felt more conspicuous and vulnerable carrying a laptop bag.

9 As a result of the project, the local community have successfully bid to have an electricity supply brought to them, to support their educational development.
**General Limitations of the study**

Time for training was inadequate and limited solely to functional rather than curriculum related purposes. No time was spent exploring curriculum or classroom related uses. In feedback teachers in both countries mentioned the need for more training (e.g. *to show how to best use all the features*; *sometimes when using it I discover many things I don’t know which makes me feel that I need more training*; *limitation- other programmes I am not aware of*).

**Summary of findings**

When the DEEP project team introduced the hand held computers into the research project, there was considerable scepticism about the appropriateness of the device from many quarters.

>>insert Table 1<<
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<thead>
<tr>
<th>Common Perceptions / Counter-arguments encountered whilst establishing the project</th>
<th>Experiences and Research Evidence arising from project implementation.</th>
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<tbody>
<tr>
<td>• State of the art, hand held personal computers - traditionally seen as a tool for affluent business executives – are inappropriate tools for teachers of the global south, particularly in remote rural areas.</td>
<td>• Project teachers report the benefits of the devices for carrying out a wide range of professional activities: the devices have helped teachers develop aspects of their professional knowledge and competences.</td>
</tr>
<tr>
<td>• The devices will either be stolen, or will not survive the rough and tumble of daily life in a rural or resource challenged urban environment</td>
<td>• Only 2 of the 54 devices used in the project have been stolen, one in South Africa, the other in the United Kingdom. After two years use, only 1 of the 54 devices was no longer in working order.</td>
</tr>
<tr>
<td>• Hand held computers will be too complex for teachers to use, especially if they are novice ICT users.</td>
<td>• The majority of project teachers find the devices ‘useful’ or ‘very useful’. Many teachers in both country contexts employ them regularly, some on a daily basis.</td>
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<tr>
<td>• Small ‘personal’ hand held computers don’t lend themselves to classroom use, especially when there are very few devices, and very many students. (This was largely the project team’s perception too…)</td>
<td>• The hand holds are used extensively in the classroom by many teachers and students. The majority of the teachers find them as useful as desktop or laptop computer.</td>
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Table 1
Discussion of findings

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

Anytime, anywhere learning

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 student to student, thus enabling it to be integrated with ease into the flow of daily activity, including in some instances, field work 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 nor does it require special furnishing.

New tools enable new learning activities

The effects of the hand held on new learning activities cannot be assessed independently of the adjacent technologies the teachers are using as part of DEEP overall (Leach et al, op cit.). However in classroom visits the researchers observed the device being used for the following learning activities that were new to teachers and students including: peer tutoring,
shared writing; language work using a voice recorder; use of a calculator for mathematical calculations; use of a camera to support curriculum related work; collaborative research tasks; storing and redrafting written stories; ‘reading’ and interpreting multi-media stories.

Many of the teachers that were observed integrating the hand held into classroom activity included the hand held in their end of project concept maps. Rebecca’s project partner Mutsa (Imimoya School), for example, gave her concept map ‘Teaching and Learning with ICT’ four equally weighted branches entitled: ‘Learning’; ‘Resources’; ‘Research’ and ‘Jornada’, this fourth branch was annotated thus: ‘I record, take photographs, write, read stories’. Egyptian teacher, Mona’s end of project concept map Using ICT for Learning also integrates the affordance of the hand held, relating it directly to classroom practice: Jornada – photographing things that serve the class- to know some information- means of drawing attention- to know more.
***Enhanced professionalism***

"...I don’t think I can teach without [ICT] again (laughs)!!can’t go back and teach differently in the future...”

*(Connie, Teacher interview)*

What of the more lasting effects of the hand helds, 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! ... its now that I can feel myself as a professional._

_Warm greetings. Bye_

*(E-Mail from Sara, 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 the personal hand held computer appears to have modified the way many teachers organize, think about, and indeed carry out aspects of their work, as well as the way in which
they work with others\footnote{Again we need to take account here of the adjacent technologies (laptop and printer) and the DEEP project resources: some teachers have made similar comments about the affordances of the laptops, and some have cited the DEEP programme and its resources as encouraging and developing the planning process.}. Highly suited to organizational tasks, data collection and planning is much easier to carry out. The device is ready to hand, when any one of a range of applications is required.

The hand held not only enables effective organisation, it facilitates reuse, revision and storage of a wide range of professional resources. In commenting on how the hand held computer has supported both personal and professional development one teacher, Nadia describes its marked impact on her capacity to plan lessons and schemes of work as follows:

“I’ve begun to think how I could manage my classroom. At first we didn’t use it to be honest with you. It saves time because at home I can prepare my lessons. I then download to the PC [at school]. This didn’t happen before. This is better than using the pen! Preparing and planning lessons was routine, but now I came to be creative”. (Teacher interview).

**Collaboration and shared professional learning**

The use of the hand held has facilitated new forms of collaboration between project partners and local cluster groups. Teachers use infrared ‘beaming’ to exchange resources. In ‘cluster’ sessions researchers attended, teachers were observed sharing the devices as they looked at each other’s lesson plans, photographs, recordings and presentations that they or their students 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 easy means of producing, storing, and adapting their work. Resources of the type most teachers in the Global North take for granted - textbooks, libraries, worksheets, calculators, databases, storerooms, mark books, dictionaries, filing cabinets - are not available. One of the project teachers in a rural context 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 students had to be read or 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 can be highly constrained and transient. Every day lesson content has to be approached from scratch. The ability to store and then share ideas, plans and resources at a later date with colleagues was 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 holds at training sessions. Such activity encouraged shared learning and the possibility for professional updating.
New Classroom practices
As we have noted, students were observed using the hand helds for a wide variety of activities in and around the classroom. The researchers also accompanied students from two of the project schools on a fieldtrip to a third local primary school to investigate their use of solar power. Students were observed sharing the hand held to take photos, record interviews and make notes. They were fluent users of the device.

‘They are really curious to learn now, comments Miriam, one of the teachers.’ 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)

Nadia also notes changes in her approach to teaching. The concept map below, completed twelve months into the project, indicates some of the classroom practices that she now knows can be supported through ICT including ‘games to serve in enriching various subjects in students’ knowledge’; ‘peer teaching where students teach and exchange
experiences among themselves’; and ‘using pictures from the internet to attract students’ attention’.

Impact on practice has been important for Nadia. Previously her teaching consisted wholly of didactic teaching: ‘I began to use cooperative learning and I think this strategy has made the classroom more living’. She feels that students are interacting differently with her ‘they even began to give me floppy discs with their own work on it!’. Students have seen lessons, and their teachers, in a new light ‘They are willing to participate in the activities….these new strategies made the classroom more lively, students are very happy, they want to discover more and more now’.

**Dignity and self esteem**
Throughout the study, many project teachers have provided testimony to the way in which their self esteem and professionalism has been raised by use of the hand held computer, together with the adjacent technologies.
within the DEEP project. Ownership of the hand holds marks a change in status and professional competence.

Nadia felt confident enough to present curriculum work on fractions she’d developed to over 100 peers at a maths in-service meeting. Hitherto, she had been a silent attendee. Tabo, who has used the computers extensively to create isiXhosa materials for his learners, entered his learners into an international story writing competition and recently made a successful bid for 20 computers for his rural school; he hopes a phone line will be installed soon. 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.

Rachel 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. Mutsa 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.’ Participants also explained that this sense of professional affirmation was not limited to project teachers alone, but extends to colleagues and parents:

‘Great excitement from parents and teachers … so there has been great enthusiasm’. ‘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' [School Principal Interview].

**Conclusion: 4D technologies for teacher education**

This small-scale study indicates 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 leapfrogging expensive mistakes made by more affluent countries. We have cited influential large-scale studies that demonstrate the benefits of ‘anytime, anywhere’ learning technologies for education and learning in the Global North. (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 software is being developed for hand holds 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. In interviews at least half of the schools commented on the improved grades and outcomes of students in classes using the ICT, particularly in literacy. They also reported on increased student motivation and in some cases increased student 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 was observed extensively by the project 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. Digital technologies for teacher development, we suggest, can support processes and outcomes that are:

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

They should in the process bring about:

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

Further questions arise as a result of this study, which the project hopes to explore 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 respect of teacher development, less viable by other means?

• How can hand held computers support the task of school principals and educational leaders?
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