

## **4d Technologies: Can ICT Make A Real Difference In Achieving The Goal Of Universal Primary Education?**

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

***Jenny Leach and Bob Moon***

The Open University, United Kingdom

Over 100 million children world-wide 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**

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.

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.

DEEP is funded by the Department for International Development (DFID) and coordinated by the Open University (UK), with the University of Fort Hare (South Africa) and the Programme, Planning and Monitoring Unit (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. This evaluation aims to assess the possibilities and constraints afforded by the hand held 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:

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.

### Context 1: 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 68 million; GDP per head is \$1,140. 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 multimedia lab, funded and specified to a common format by the Ministry of Education, with minimum of one 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: 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 45.9 million and a GDP per head of \$2,200. In 2001 there 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. 14 had never used a computer prior to the project and the majority (18) had never used the internet. Of the 10 teachers who had used computers, five had 'occasionally' used them in relation to teaching.

Most people in 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 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



E\_\_\_\_\_ 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 chalk board and chalk. She has access to a rudimentary library of outdated reading books, most of which are in English (which is not the mother tongue of her pupils) and distant in content from their life experiences. The opportunities to update her subject knowledge for teaching or pedagogic practice have been as sparse as the teaching resources available to her.

During the course 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 teaching.

"[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"

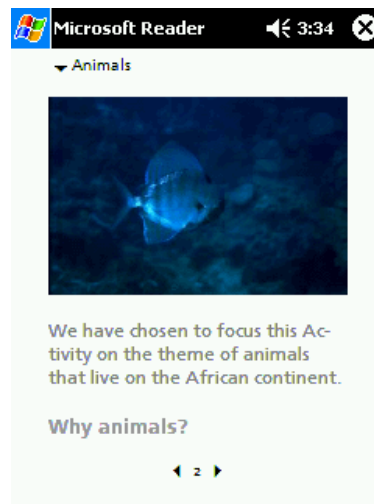
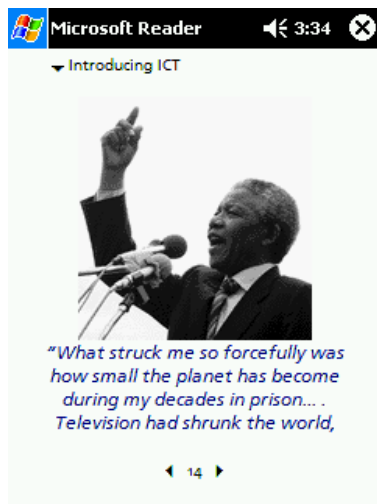
E\_\_\_ encourages her pupils to use the hand held as a learning tool, and to store their work on it. They use the notes, memo, calculator and games functions 'frequently' and the voice recorder occasionally too.

"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 2003 the DEEP project team secured two small grants from the Open University and Hewlett Packard that enabled every teacher participant (and both project coordinators) to be provided with their own hand held computer and pocket camera, together with docking station and adaptor<sup>1</sup>. These devices were viewed as an additional source of support for the teachers, given their minimal ICT experience and access (i.e. the school's multi media lab in Cairo; a shared lap top in Eastern Cape). 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, were installed on the hand helds. 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 a brief training session.



## 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 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

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<sup>1</sup> Hewlett Packard Jornada 560 (Colour 32MB, with 206 MHz processor)

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 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 pupil 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 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 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).

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 to fit criteria drawn up by the local coordinators. The core of the DEEP project is the use of ICT in classrooms and community settings by teachers who are interested in developing their teaching and this study relies primarily on their reported experiences of using the hand held computers. 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.

### **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, e-mails, 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 Cairo experience**

Overall the hand held was seen as 'useful' by the Egyptian teachers. 19 use it at least once a week or more, 3 use it daily. Over half considered that the hand held 'helped

their ICT skills'. The majority (17) thought it helped their 'understanding of the language and concepts of ICT'. 9 of the teachers thought that it was 'of more' or of 'equal' value to other computers they had used. Although 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'), some of the teachers also used the device with pupils in the classroom.

### **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 of the project. At the time of writing this has still not been available, though there is some possibility that the project teachers may become 'beta-testers' for an Arabic version of the OS in 2004.

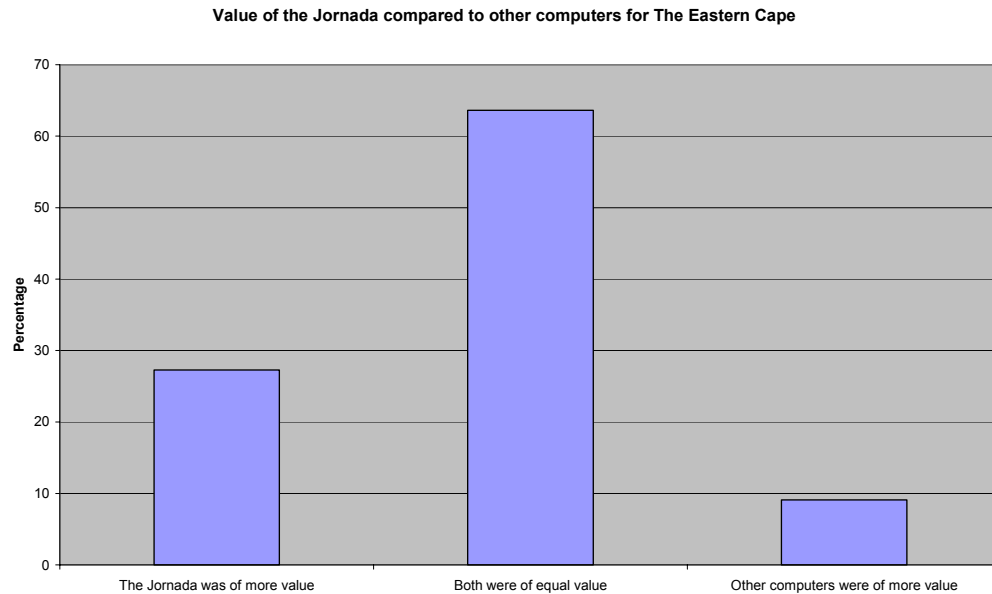
Research findings suggest that the lack of support for Arabic has proved a disincentive for the teachers in Cairo to make full use of the hand helds in their writing practices. All the Cairo teachers mentioned at some point in the survey that the language issue constrained their use of the device. The functions most frequently used for personal purposes in Cairo have been those that are the least language dependent (e.g. calculator and games).

### **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 use 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 hand-helds 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.

**Table 1**



**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<sup>2</sup>. 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.

**Summary of findings**

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

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<sup>2</sup> 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.

**Table 2**

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<i>Common Perceptions / Counter-arguments encountered whilst establishing the project</i>	<i>Experiences and Research Evidence arising from project implementation.</i>
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.	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.
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	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 were no longer in working order.
Hand held computers will be too complex for teachers to use, especially if they are novice ICT users.	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.
Small ‘personal’ hand held computers don’t lend themselves to classroom use, especially when there are very few devices, and very many pupils. (This was largely the project team’s perception too...)	The hand helds are used extensively in the classroom by many teachers and pupils. The majority of the teachers find them as useful as desktop or laptop computer.

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## 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 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. Hand helds 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, 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 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 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 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 <sup>3</sup>, 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. In commenting on how the hand held computer has supported both personal and professional development one Egyptian teacher described its marked impact on her capacity to plan lessons and schemes of work:

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<sup>3</sup> We also 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.

“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”.  
Project teacher.

### **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.

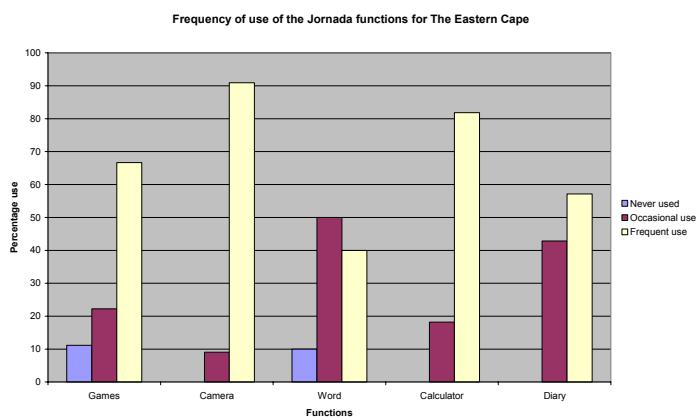
The project team was also able to transfer new professional resources to the hand helds at training sessions. Such activity encouraged shared learning and the possibility for professional updating.

### **New Classroom practices**

Pupils in Cairo were observed using the hand helds in the classroom for a variety of activities including: note-making; mathematical activities; group work; photography. In one lesson focusing on ‘our local environment’, pupils worked in groups outside the school, using the hand held to make notes and taking pictures. 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’.

Computer games are particularly popular in the Eastern Cape classrooms, not solely in terms of personal recreation ('learners learn numeracy skills by playing solitaire').

**Table 3**



'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)

Pupils in the Eastern Cape were observed using the hand helds 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 hand held 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. The concept map below, completed in March, 2003, twelve months into the project, shows some of the activities that she now knows can be supported through ICT including 'games to





Participants also explained that 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**

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 leap frogging 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 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 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 pupils;
- and
- *Dignity*: raising the confidence and self-esteem of pupils, 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 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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## **AUTHOR INFORMATION**

Jenny Leach, Bob Moon, Rakhee Patel, Alexis Peters, Thomas Power, Atef Ahmed and Shumi Makalima  
Research Group on International Development in Teacher Education across Cultures and Societies (RITES), The Open University, UK  
University of Fort Hare, South Africa  
Programme, Planning and Monitoring Unit, Cairo, Egypt  
E-mail: [fels-deep@open.ac.uk](mailto:fels-deep@open.ac.uk)