Exploring the Use of Mobile Devices to Support Teacher Education

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INTRODUCTION

Mobile learning has been clearly identified as an agenda in need of research (Rushby, 2012) however, it appears that there is some way to go yet before teachers will confidently open up their classrooms to students carrying personal, handheld devices, whether mobile phones, iPods or Personal Digital Assistants (PDAs). One of the reasons for this is that teachers themselves tend not to have been taught as mobile learners nor how to teach with mobile devices; others relate to the classroom context itself (Terras & Ramsay, 2012) and the disruptive nature of mobile technology (Sharples, 2002). As will be seen, this has consequences for those researching innovations in teaching and learning technology and this chapter provides evidence of the way the school based learning environment affects teachers' responses to initiatives set up to explore teaching and learning with mobile devices. It is set in the context of a series of teacher education research initiatives funded by the UK Training and Development Agency for Schools (TDA) that were intended to raise teacher trainees' awareness of and competence in managing effective learning opportunities with new technologies. It presents an overview of a series of small-scale investigations aimed at identifying the potential of handheld mobile devices, mostly PDAs (early Smartphones), in supporting pre-service teachers with both their teaching and learning whilst on placement in schools.

CURRENT SCIENTIFIC KNOWLEDGE IN USING MOBILE PHONES FOR TEACHER EDUCATION

Pre-service teachers (initial teacher trainees) in the UK are more than likely to be university or college students dividing their time between studying more theoretically in higher education institutions and more practically on work placement in schools. Thus a considerable part of their learning (current UK government regulations require at least two-thirds of the national one year postgraduate teacher training programme to be based in schools) takes place in the workplace context. Benefits to workplace learning from giving university and college students access to internet enabled PDAs or Smartphones had been identified in the early 2000s by both the EU funded, global Mobilearn project (see http://www.mobilearn.org/) and the UK's Joint Information Systems Committee (JISC). The JISC review of innovative practice with e-learning in further and higher education (JISC, 2005) suggested that the portability, any time, any place connectivity and immediacy of communication of mobile devices were key to their success. For example, having PDAs was seen to enable flexible and timely access to the university's e-learning resources and immediacy of communication through voice call, texting or email, all of which were reported to lead to empowerment of and more effective management of learning (especially in dispersed communities such as those found in initial teacher education).

A more theoretical approach arose out of the Mobilearn project which involved 24 partners from Europe, Israel, Switzerland, USA and Australia in exploring context-sensitive approaches to informal, problem-based and workplace learning. This was one of the earliest mobile learning projects to involve Professor Mike Sharples (Sharples, 2002) now with the Open University, UK. Other pioneers in the field include Professor Agnes Kukulska-Hulme, also of the Open University and Professor John Traxler of Wolverhampton University who together edited the first handbook of mobile learning (Kukulska-Hulme & Traxler, 2005). At the time Professor Sharples was with University of Birmingham and he and his colleagues: Laura Naismith, Peter Lonsdale and Giasemi Vavoula's contributions to this project led them being asked to produce a review of the then current state of mobile learning research for Futurelab (Naismith et al, 2004). Many of the above scholars are still leaders in the topic of mobile learning. In this early review, they classified effective mobile learning activities (including those conducted with children and the general public as well as university and college students) by their underpinning ethos. Four of the resulting categories are linked to aspects of learning theory:

- Behaviourist, as using PDAs and/or mobile phones is rewarding,
- Constructivist, as handheld devices allow students to build knowledge through bringing together information from different locations,
- Situated, as the built knowledge is authentically situated in a relevant context and
- Collaborative, as any time, any place communication enables increased collaborative learning opportunities.

Two further categories relate more to context of the learning activity and method of application:

- Informal and lifelong learning and
- Learning and teaching support.

It is this last area of learning and teaching support that is the subject of this chapter. It is particularly relevant to initial teacher education where students move between university and school based practice and are expected to acquire, decipher and understand a wealth of information, both pedagogical and practical, in the process. This information may come from dedicated software, electronic books, or the Web, especially via the course linked Virtual Learning Environment (VLE), or from previously recorded pupil data or via communications with peers and tutors. In particular, the students need access to the documentation of the various UK statutory requirements for schools including the National Curriculum and information to supplement their subject knowledge such as data, vocabulary and teaching resources. Additionally the national requirement that postgraduate trainee teachers spend 24 of the 36 weeks of their programme in a partner school rather than in the university makes access to conventional information sources for students such as the university library difficult. Then there is the documentation associated with being on a teacher education programme such as timetables, assessment guidance, pupil mark books, lesson observation records and lesson plan proformas.

Also, whilst the trainees are directly supported by a mentor from the school when on placement, their university tutor needs feedback on their progress and to assure themselves of their wellbeing. Access to email and the internet has become central to managing this however, whilst all community schools in England now have internet connected desktop computers or laptops, our experience is that the socio-cultural context within the schools means that trainee teachers are reluctant to use these. They tend to be perceived as belonging to the students or other members of staff. Providing trainee teachers with handheld mobile devices such as PDAs was seen by the project team as a way of resolving this issue. Lastly, the use of mobile, handheld technologies for teaching and learning support is particularly relevant to the trainee teacher, who is expected to teach as well

as learn. Early work with teachers using PDAs in schools (Perry, 2003) had shown that they offer considerable potential to make teachers' management and presentation of information more efficient. One Science teacher noted "I would never willingly go without one now; it is my instantly accessible encyclopaedia, thesaurus, periodic table, diary, register/mark book, world map and even star chart!".

Indeed teacher educators in other countries have also been exploring how to support trainee teachers' use of handheld technologies in both their learning and with teaching in the classroom environment. An early study in Finland (Seppälä & Alamäki, 2003) showed that both trainees and their supervisors were willing, especially where images were involved, to send and receive feedback via SMS on mobile phones. In the US a small scale study of science interns by Pederson and Marek (2007) using PDAs found that all of the informants indicated that they would be likely or more likely to use technology in teaching science in future classrooms based on their experiences during the project. In Australia, Herrington et al. (2009) from the Faulty of Education at the University of Wollongong conducted a faculty wide action learning project with teacher educators from a wide range of subject areas to investigate the educational potential of PDAs and iPods. They highlight the opportunities they found for spontaneous learning, though the mobile technology was not found to be as good as other dedicated tools such as laptops or digital cameras, having it immediately to hand enabled the lecturers to make the most of context relevant learning opportunities for their students. In particular they note that "pre-service teachers in this project were able to capitalise on the spontaneous events occurring in their classrooms in order to capture perspectives of pedagogical approaches for later exploration" (p.142). Lieberman and Pointer Mace (2010) make the point that that professional development within teacher communities would benefit from teachers sharing such instances and what they have learned from them via online social networking

tools. They note that "many of us now have daily access to computers, cell phone cameras, and other multimedia tools. We use them to connect with our friends and families, but we have yet to capture the potential of these connections for professional learning." (p. 82).

However, using handhelds in class is a very different social environment to using them at home. When Gado, Ferguson and van t'Hooft (2006) created a university based laboratory at Cleveland State University in Ohio to model strategies for integration of mobile technology into science methods courses for their pre-service teachers they found the classroom and school environment to be a key factor (alongside the curriculum and students' and their teachers' own technological experience and attitudes) affecting effective integration of handheld technology for instruction and learning. When the environment is conducive they report finding that handheld-based science activities can enhance pre-service teachers' inquiry abilities, organizational skills, engagement in science content learning, and attitudes and self-efficacy. Changing practice to include handhelds however, can be quite an undertaking. Crowe (2007), another teacher educator from Ohio at Kent State University, similarly enthused by the 1:1 authentic learning possibilities of teaching with mobile devices but working without the back up of a large project team became much less enthusiastic over time. She cites issues such as compatibility with other classroom hardware and student scepticism as interfering with the successful adoption of the hoped for ubiquitous computing environment. Others have also found that working with PDAs and mobile devices is not always constructive or even successful. Trinder, Magill and Roy (2005) point to a host of problems; the need to remember to recharge the battery and to synchronise with the host computer are common to all operating systems, as is the small screen size and various other software issues are platform specific. Such issues are common, much of this kind of research remains small scale and projects that address scalability and sustainability issues are rare. Even one

such project, an Australian whole school mobile learning initiative (Ng & Nicholas, 2012), was significantly affected by technical issues impacting on teachers' and students' attitudes. Ng and Nicholas' (2012) also highlight the problem for schools of the constantly changing nature of handheld devices with manufacturers focusing on pushing out annual 'upgrades' in their focus on a person centred model for sustainable mobile learning in schools.

THE RESEARCH PROJECTS

Method

Over a three year period starting in October 2004 the use of handheld PDAs was trialled on the University of Bristol PGCE in order to identify whether and where the potential opportunities for learning and teaching support described above were borne out in practice. At first the PDAs were made available to groups of volunteer student science teachers selected at opportunity and then the range of participants was widened to include practicing teachers themselves and modern foreign language (MFL) student teachers. The choice of school subjects was dictated largely by opportunity though it was clear by the early 2000s that PDAs had found a home within school science (Soloway et al, 1999; Tinker & Krajcik, 2001). In each of the three investigations the students or teachers became participant action researchers acting on their teaching and learning by means of the PDA and then reflecting on and amending their practice (Wadsworth, 2001).

In the first project, reported in Wishart et al. (2007), 14 student teachers following the one-year science PGCE (postgraduate teacher training programme) were given either a Windows Pocket PC or a Palm OS-based handheld and trained in its use. Data packages including web pages and email were provided by Vodafone as it had proved reliable in the project area in a pilot test though students would be expected to pay for any voice calls they made. During the training student teachers were shown how the PDAs have potential to support them in:

- Collaborating via the VLE (Blackboard) discussion groups and email,
- Accessing course documentation (on PDA or via Blackboard or via synchronisation with a PC),
- Just-in-time acquisition of knowledge from the Web,
- Acquisition of science information from e-books, data tables and encyclopaedias,
- Organising commitments, lesson plans and timetables,
- Recording and analysing laboratory results,
- Recording pupil attendance and grades,
- Capturing images e.g. of experiments and demonstrations for redisplay to reinforce pupil knowledge or of their teaching to evidence progress and
- Maintaining a reflective web log (blog) that could allow them to record lesson evaluations and other reflections on their teaching.

This pattern of a one-year loan was repeated in a second project (reported in detail in Wishart, 2009) but this time with only the six teacher trainees placed (at different times during the year) in a single secondary school and simultaneously providing PDAs running Windows Mobile 5 with internet connectivity for data etc both via Wi-Fi and a national mobile phone network for all the 13 science teachers in the school. Practising teacher engagement was sought to remove constraints reported by the first group of student teachers who were quick to spot the disruptive effect of having a handheld device in school. They had reported that bringing out the PDA in class drew unwarranted attention to them. It was also anticipated that, by providing PDAs for all the teachers, there would be increased involvement of the school based mentors in the e-learning community linked to the initial teacher training course.

In the third project (reported in Wishart, 2008), the remaining Wi-Fi enabled PDAs were loaned for the academic year to a group of seven modern foreign language (MFL) student teachers to gain information from a contrasting subject context.

In each case the student teachers involved in the project reported back on their experiences of PDA use at key points in the PGCE year via a short, online questionnaire at half term breaks and at the end of their school based teaching practice placements and via a face to face interview at the end of their course. Up to three focus groups were also arranged at opportunity each year to collect richer details and share experiences on PDA use. Quantitative data on frequency of use of the different software applications by the participants was collected via the questionnaires whereas qualitative data describing participants' perceptions of their experiences during the project was collected via the interviews and focus groups. Thematic content analysis, where a theme is identified as something important about the data in relation to the research question (Braun & Clarke, 2006), was used to analyse the qualitative data to discover salient and/or re-occurring themes.

Results

Results from the Original 14 Student Science Teachers

Three of these student teachers used the PDAs on a regular basis in wide variety of locations throughout the year and another eight used theirs intermittently throughout the year. The last three gave up on the PDA during the year citing both hardware issues and challenges arising from the socio-cultural context in schools. Hardware problems cited were the loss of data if the battery was not regularly recharged and difficulties in synchronisation with school computers whereas contextual issues included embarrassment at the attention the PDA attracted from pupils and lack of time to continue to explore the use of the PDA under the pressure of teaching, planning for teaching and writing up university assignments.

As shown in Figure 1 the activities that involved using a PDA successfully for teaching and learning support most frequently reported by the 14 students were:

- The 'to do' list and/or the calendar to support personal organization,
- Using the internet as a resource (mostly Google),
- Using MS Word for lesson evaluations, observations etc.

In addition the three enthusiasts used MS Excel to produce spreadsheets for:

- Auditing their teaching competences against the national qualified teacher status (QTS) standards, and
- Recording class attendance, grades and commendations.

It was observed that students who made more personal use of the PDA were more likely to use the PDA more often for learning and teaching support. The personal activities that were reported to be useful were:

- Email,
- To do / task list,
- SMS/texting,
- Calendar/date book for schedule/timetable,
- Internet for personal use – recipes, maps, shopping,
- Taking photos, and
- Making notes.

Whilst the two types of PDAs had similar functionality the Windows based PDAs were largely preferred by the students to the Palm based ones for their familiarity in operation.

The eight students, who used the PDAs intermittently throughout the year, were the most affected by the sociocultural context of being a

Figure 1. Software tools reported to be helpful in supporting teaching, learning and to the individual

PDA tool that was most helpful ...
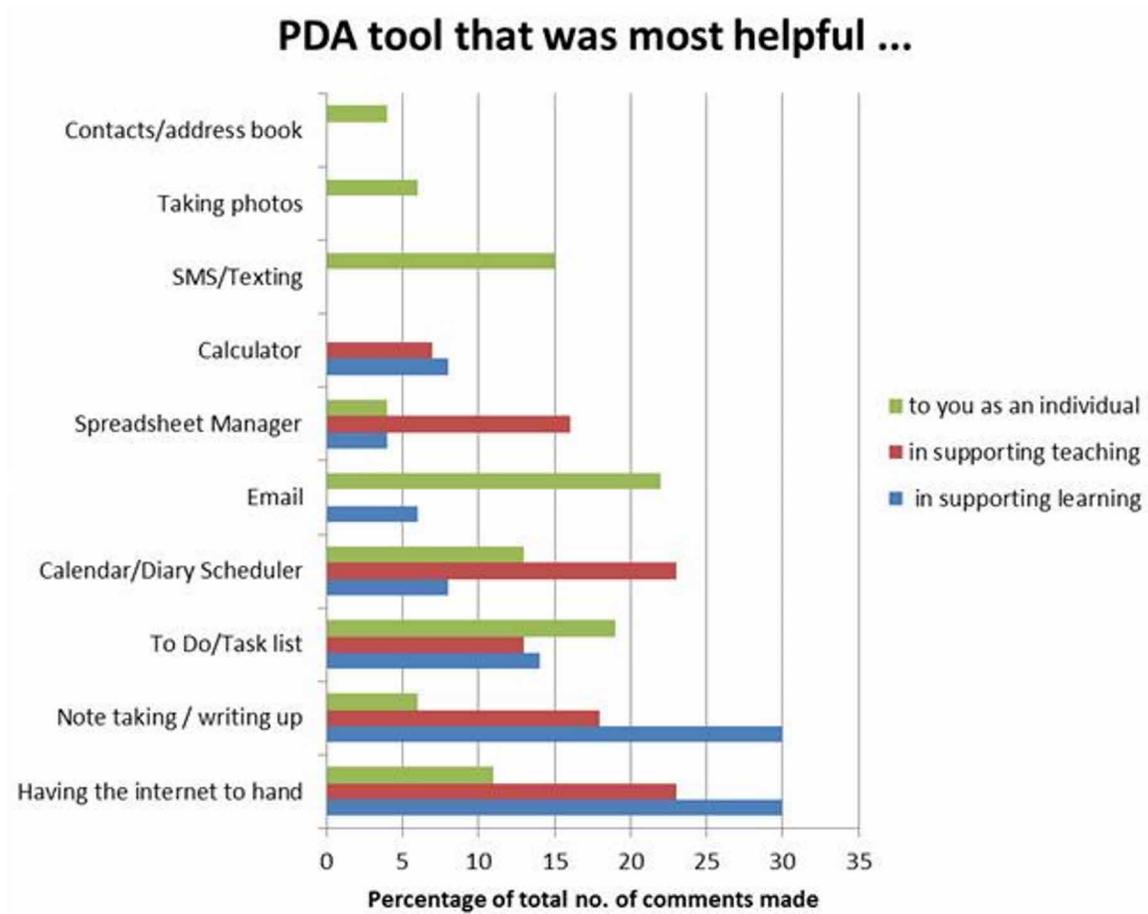
student in a school. Whilst recognising that having internet access on the PDA extended their capability to answer questions and plan lessons and having Word enhanced their recording of their observations for later assignments, they tended to feel uncomfortable both about the attention gained by using the PDA in class or about asking the school to resolve hardware issues.

Results from the Second Study: The 13 Experienced School Science Teachers

Again the amount of use made of the PDAs varied extensively by individual ranging this time from almost no use to use every day at home and at school. Successful activities using a PDA to support teaching were most frequently reported to be:

- Using MS Word for making notes in meetings and/or lesson observations,
- Taking video or photos (both of students e.g. during a one-off, special session such as a role play or of a demonstration to play back to the pupils later and of other colleagues to evidence teaching practice),
- Searching /researching on the internet, and
- Using the calendar to manage scheduling.

There was only one enthusiast in the school who, in addition to the above used his PDA for

- Email,
- Calculator,
- To do / task list,

- Spreadsheets for attendance and grades, commendations etc (MS Excel), and
- Voice call.

Towards the end of the project, he reported:

I will be at a great loss if you reclaim the PDA from me. I personally find it very useful for collecting data, class marks, making notes during lessons, doing student observations, sharing files with colleagues and many others.

Results from the Second Study: The 6 Student Teachers

In this instance there was more consistent but limited use, with four of the six students having given up on the PDA by the end of the training year. Having to keep these early 'Smartphones' charged to avoid loss of personal data was a perennial problem and data loss over the vacation happened to at least two of these students. In congruence with results from the initial project, information management was the most commonly reported use with the two applications cited by the student teachers as most useful being the calendar for scheduling and the task list for organizing their multiple commitments. They also used Word for making notes on lesson observations and for receiving feedback from experienced teachers on their own lessons. The trainee teachers generally reported a feeling of confidence about their use of the PDA, especially being able to access the internet wherever they happened to be for both personal and professional information. The phrase "*ICT at your side and not in your face*" arose during the discussion about PDA use in one of the focus groups conducted during this academic year. That is to say that the ability to take out the handheld device, use it to access the necessary information and then to hide it back in a pocket or bag led to it being perceived by these students as an educational technology that was more manageable in front of pupils than a laptop computer.

Results from the Third Study: The 7 Modern foreign Language (MFL) Student Teachers

Seven student volunteers were loaned the Windows based PDAs and given training in their use. However, during this particular project the PDAs were used much less than had been anticipated given previous experience with the science student teachers. The students recognised their potential but were unwilling to spend time on the exploration necessary to put this potential into practice. Established practices in employing ICT to support MFL teaching such 'language labs' and the socio-cultural context in school had even more impact on the MFL student teachers than the science trainees. One student highlighted the different subject cultures herself, she noted

And I think if you look at the use of ICT in MFL, although we're very competent at certain areas a lot of us need the idiot's guide… to put it bluntly… on how to do it. Whereas when I've spoken to my friends who do science, maths and even humanities… they seemed to use ICT much more readily and easily…

Where the PDAs really did come into their own in MFL classes was for capturing on-the-spot events when pre-booked equipment was not available. One student reported:

That's where […] where I think it is useful. If you haven't got a camcorder, you haven't got microphones, you're not in a computer suite, then […] being able to hold it up and instantly record is useful.

Several of the student teachers however would have preferred to use their own mobile phones for capturing class events as the cameras on their phones had much better resolution and picture quality. Thus being involved in the study had engaged them in thinking about ways in which using camera phones for video or audio capture

of their classes could support their teaching, but these were often overwhelmed by schools' bans on pupils' use of mobile phones. This trainee illustrates his dilemma:

…phones were being used in school in class sometimes and then half way through the term they introduced a new rule that phones were not to be used […] and if they were seen in lessons they would be confiscated by the teacher […] So I thought […] with that regulation coming in, for me to get my phone out, there would have been a bit of uproar […]

The results of the post-project interviews clearly indicated that the MFL students were not yet confident in their pedagogical identities and most felt they could not disrupt the established practice with the novel technology. When they did use the PDAs, applications that they reported to be most effective were those that enabled the capture of on-the-spot events and reflections such as video and making notes using either the on-screen keyboard or by handwriting recognition.

DISCUSSION AND CONCLUSION

In this series of small scale studies there were really only three applications on the PDAs that maintained their popularity with most of the forty teachers and trainees in the different investigations. These appeared to be key to managing both teaching and learning of how to teach and included the calendar or diary scheduler for organising yourself, the spreadsheet of attendance or mark book for organising your pupils and the use of a word processor to make notes on information and events immediately they are encountered. This information which often contained reflections on the teaching process can then be incorporated quickly and easily into the assessed components of the PGCE course. The effectiveness of this is reinforced by this student teacher's comment, "During teaching practice I have found myself constantly bombarded with new and noteworthy information (e.g. scientific facts, ideas for teaching approaches, school procedures, evidence for QTS standards etc.). The PDA has allowed me to keep meaningful notes of this information, and structure the information (i.e. file) in a way that allows me to access it easily." Using the PDA to make notes was also reported by the MFL students who, in addition, highlighted use of the camera (both video and still). The camera was used at opportunity to record personal and work events by both teachers and trainees and accessing the internet and/or email when a desktop computer was unavailable was also popular. The classroom based images were shared in support of professional learning amongst the participating student teachers but not online as proposed by Lieberman and Pointer Mace (2010). As will be elaborated on, the trainees were very cautious in respect of using cameras in a classroom.

The communications capability of the PDA was also essential to its success. Having the internet available as a portable resource welcomed by the students, it was the software application that, though used less than the others, the original group of science student teachers considered to be most helpful to both teaching and learning. It appears that, having the internet literally 'in your hand' can enable the teacher with PDA to act as a distributed intelligence system (Pea, 1993), for the wealth of information on the internet means you can use the PDA to answer virtually any question from your pupils. One student science teacher even used 'chat' on a PDA successfully during a lesson to solicit answers to pupils' questions about the structure of the heart from medical students he knew. Finally, email for keeping in touch with the university tutor, other students, family and friends can provide valued support for students who are working on school placements away from the rest of their peers.

However, the most obvious outcome in all three studies was that the socio-cultural context of PDA use in school by a teacher heavily affected their use; in many schools in the UK the use of

mobile phones by pupils is banned and it is rare to see even teachers using handheld mobile devices or Smartphones in lessons. These circumstances led to feelings of discomfort amongst the student teachers about getting the PDA out in front of the class. One student found the interest it generated amongst her pupils detracted from her teaching and another reported concern about having it stolen. In the second study where every member of a science department was allocated a PDA there were noticeably fewer reports of the devices drawing unwarranted attention but still only small numbers of enthusiasts continued to use the devices. Of Gado, Ferguson and van t'Hooft (2006)'s five conditions that can affect the integration of handheld technology for instruction and learning it was clear that the school environment was the most influential.

One particularly salient social issue that prevented more students taking pictures to use in their teaching was their concern about the number and level of permissions required to photograph children. Even where the students had been reminded of the opportunities for capturing multimedia evidence of their progress for assessment by their tutor and permission for such image capture had been gained from their schools, they were concerned as to how taking photos would be perceived and few took photos of children participating in activities. Those that were taken were mainly of outside classroom events.

Thus it appears that strong socio-cultural pressures militate against the use of personal mobile devices to support teaching and learning in UK schools. This isn't surprising, Wertsch (1991) makes it clear that actions mediated by technological tools will be situated within the current social and cultural climate not only of the institution but also of the social interactions between the student teacher, the class and the class teacher. However, it is in apparent conflict with the accepted concept of schools as workplaces with expansive learning environments i.e. ones where there is support for trainees and employees as learners with workplace learning aligned well with broader organisational

goals and recognition for staff progression and professional development (Evans & Fuller, 2006). Whilst the teachers and trainees in this study had formal permission from all the schools involved to explore ways in which the PDAs could be used in class in order to identify how they could support their learning and professional development, the schools' socio-cultural environments were much more restrictive. Indeed Hodkinson and Hodkinson (2005) identify the practices and cultures of the different subject departments in schools as one of three dimensions that influence teacher learning. The other two are the dispositions of the individual teacher and the management and regulatory frameworks, at school and national policy levels. In the case of handheld mobile devices such as the PDAs in this study the impact of those cultures and practices of the different departments clearly outweighed the other dimensions. Vratulis et al (2011) also report student teachers with negative attitudes to handheld technology (digital cameras to make animations in this case) and go so far as to describe the introduction of new technologies to schools by teacher trainees as 'disruptive' pedagogy. They base the concept of disruptive pedagogy on Hedberg and Freebody's (2007) distinction whereby a disruptive model requires change in teaching approaches to incorporate the learning opportunities offered by the new technology as opposed to an additive model where the new technology can be simply included in existing classroom practice.

However, in this study, the factor that had most impact on the student teachers and teachers trialling the PDAs in schools was not a pedagogical model but the fact that school rules prevent pupils from using mobile phones in the classroom. Mobile phones are largely seen as likely to be disruptive not just to the class teacher's pedagogy but to the learning of the entire class, indeed they are banned from all schools in certain states in the USA and India and even in whole countries such as Brunei and Sri Lanka. This widely held assumption, fed by all too frequent headlines about pupils uploading images from the classroom online or downloading

inappropriate material to show others in class lies at the heart of our difficulty in developing teachers' learning to use mobile technologies in the workplace. As Thomas (2008) points out school personnel ban things they believe a) encourage students to adopt improper moral values or b) waste time that should be spent pursuing the school's learning goals. Both of these can be applied to the case of mobile phones. Katz (2005) further classifies problems generated by mobile phone use by students in educational settings into four groups: disruption of class, delinquency (theft and bullying), chicanery (cheating and plagiarism) and erosion of teacher autonomy. Yet these groupings clearly result from pupil behaviour and not the technology per se. The development of teacher or student teacher learning in regard of how to effectively employ handheld mobile devices in the classroom is currently being held back by local, and, in some cases, state or national regulatory frameworks that target the tool and not the operator.

One immediate way forward would be for schools to widely accept the proposal that arose from Hartnell- Young and Heym's (2008) work investigating the use of mobile phones in English schools. This was that moving the focus of schools' acceptable use of technology policies from the devices themselves to the activities they are used for would be a useful step forward in engendering a more open climate in which to enable both teachers and pupils to explore the potential of mobile phones to support learning. This would be a timely move as, in the not too distant future, teachers will be looking at pupils potentially bringing next generation mobile devices containing pico-projectors that can project the phone's screen onto walls and tables into class. It would also enable schools to start to move toward the climate described by Caillier and Riordan (2009) in their call for teacher education to work towards the schools the world needs where teachers (and their students) can explore ways of designing new learning opportunities and learning environments with the support of new and emerging technologies.

In conclusion, it can be seen that, though the studies reported here, sadly like so many others involving new technology and teacher education, were limited to one institution and small groups some findings were consistent across cohorts. Handheld mobile devices have the potential to support both learning to teach and teaching on a pre-service teacher training programme. In particular student science teachers reported the information management functions of PDAs and Smartphones (diary and task management, making notes as documents and spread sheets recording grades, attendance etc.) to be the functions most supportive of teaching and the student foreign language teachers added using video to capturing 'one off' events. The information management, image and data capture functions can also be beneficial to the qualified teacher in managing, capturing and revisiting pupil learning. It is therefore a significant issue for teacher educators that such learning opportunities are not being capitalised on as the discomfort caused by using a technology not privileged to their pupils meant that, in the studies reported here, only a few enthusiasts really tested their mobile device to its full potential. For the student teacher enthusiasts the PDAs provided an opportunity to bring information together across time and place as images and text to aid building their understanding for university assessed work. This indicates that taking a constructivist approach to learning can help us understand ways handheld, mobile technologies can be used to enhance learning in both schools and colleges or universities. However, in order to fully develop the potential of using mobile devices including Smartphones to support teaching and learning to teach whole school, parental and even state support may well be needed.

FUTURE DIRECTIONS

Recommendations arising from this series of investigations centre on schools maintaining their expansive outlook on teacher training and

professional development with provision of support for staff learning about the potential of emerging technologies even where the learning opportunities being developed test the boundaries of what is custom and practice in schools. This support will need to recognise the importance of the different subject and classroom cultures and, in the case of handheld mobile technologies, to find ways to engage teachers and pupils together in identifying effective learning opportunities and appropriate behaviours to replace the distractions offered by such devices. There are many different models of provision of handheld technology enhanced learning in schools today from BYOD (bring your own device) to class sets of say, Apple iPads. Improving and expanding dissemination of research that engages teachers in exploring what works, where and under what circumstances will enhance our understanding of the potential benefits of mobile devices to learning and living in today's technology rich world.

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KEY TERMS AND DEFINITIONS

Handhelds: Portable, mobile devices held in the hand.

Mobile Learning: Using mobile technologies to enable learning opportunities in different locations and contexts.

PDA: Personal digital assistant, a forerunner of today's Smartphones.

Science Education: Teaching and learning of the natural and physical sciences.

Socio-cultural: Relating to both social and cultural matters.

Teacher Education / Teacher Training: Programme of study required to be followed before qualification as a teacher.