IN BRIEF

- Investigates the use of PDAs by undergraduates.
- Irrespective of their ICT skills, all students in the study were able to use the devices and complete online questionnaires.
- Security issues and the measures taken when connecting mobile devices to a wireless network or the internet are addressed.
- Describes how the least liked features – poor battery life and memory – are now largely overcome by the newer PDA devices.

Portable Digital Assistants (PDAs) in dentistry: Part II - Pilot study of PDA use in the dental clinic

P. A. Reynolds,[1] J. Harper,[2] S. Dunne,[3] M. Cox[4] and Y. K. Myint[5]

Aim To describe a simple technical evaluation of the access, security issues and uses of wireless networked PDAs in a dental clinic and report a pilot study investigating students' educational use of PDAs to access a Virtual Learning Environment (VLE) in a dental clinic. **Objectives** To undertake a technical evaluation of wireless networking to PDAs focusing on security issues, robustness of the system and accessibility particularly to educational resources. To evaluate the impact of using a PDA on undergraduate students in the dental clinic and at home. **Design** Part II describes the technical and educational evaluation of PDAs used by one group of 12 undergraduate fourth year students in the Primary Dental Care clinic. A cross over trial of six students with PDAs and six without was carried out during one semester of 12 weeks. **Methods** Technical issues such as secure internet access using wireless connectivity were addressed. An assessment of the general and educational use and the students' attitudes towards using PDAs was undertaken using online questionnaires and focus group discussions. **Results** Over 90% of participants wanted PDAs as part of their dental kit. The potential of PDA use in dental training was demonstrated by a good to excellent response by over 75% of participants to having access to online support materials, particularly videos, being able to make notes for individual study and to keep a diary of their commitments to teaching sessions. Recreational use included a 100% good to excellent response to playing games and keeping a diary. **Conclusion** The PDA proved to be a convenient and versatile mode of access to online education. Technical solutions enabled a substantial proportion of the functionality of WebCT (Web Course Tools) to be accessed by the students in a clinical environment. Both novice and experienced users were able to appreciate the use of the PDA and the less able considered that their ICT skills had improved. However, further research is needed to determine how students use a range of new technologies in their undergraduate programmes. The Dental Institute plans to recommend that all students will use this device in the future throughout their five-year curriculum, and the scoping of the implications of this recommendation is underway.

[1]*Senior Lecturer and Deputy Director of Education (Flexible Learning), King's College London Dental Institute, Centre of Flexible Learning in Dentistry, Floor 3, Strand Bridge House, 138-142 Strand, London WC2R 1HH; [2]IT Manager, King's College London Dental Institute, King's College Hospital NHS Foundation Trust, Caldecot Road Denmark Hill, London SE5 9RW; [3]Professor and Head of Primary Dental Care, King's College London Dental Institute, Caldecot Road, Denmark Hill, London SE5 9RW; [4]Emerita Professor of ICT in Education and Senior Research Fellow, Dept. Education and Professional Studies, School of Social Science and Public Policy, King's College London, Franklin Wilkins Building, Stamford Street, London SE1 7NH; [5]General Dental Practitioner, 6 Mill Court, Ashford, Kent TN24 8DN
*Correspondence to: Dr Patricia Reynolds
Email: p.a.reynolds@kcl.ac.uk

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INTRODUCTION

Rationale

The use of PDAs in clinical dentistry is yet to be established, although clear applications have already been demonstrated in some areas such as orthodontics for reading journal articles, storing digital images, giving lecture presentations using PowerPoint™, collecting audit data, completing clinical logbooks and for personal information management.[1] PDA-specific resources and content are in many ways the 'missing links' of virtually based learning support. While studies indicate that online questionnaires, interactive quizzes and web-based course material are popular with students and lecturers alike, there is much potential for development. In the USA, for example, there are many environment-specific educational software applications developed for PDA use.[2]

PDAs are relatively affordable when compared to laptop or desktop computers, but many budget-conscious students cannot afford them and most educational PDA use has been sponsored by manufacturers or public programmes as in this study. Some consideration also needs to be given to students' choice,

access and support of both PDAs and supporting networks in the future. Some models – those with larger screens – are more suited to specific tasks such as reading; others may be smaller or less expensive.[3] The initial electronic diary market declined by 4.6% in the first quarter of 2004 as smart phones and small handheld PCs begin to move centre stage.[4] This new generation of PDA technology including the new iPOD™ products is now reaching reliable levels of maturity, and may well find favour in certain sectors of the market, for example education.[5] As the developing mobile technology industry standardises connectivity and equipment, testing a generic wireless network system and standard pocket PC in this study was deemed highly appropriate to avoid creating a 'false start' situation that ultimately disappoints users.[6,7]

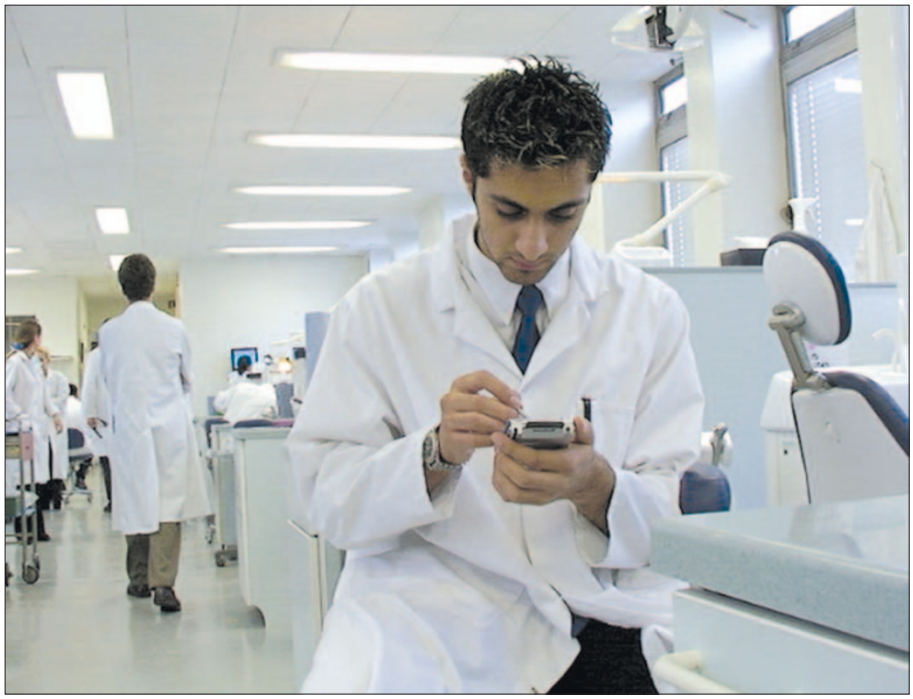

Fig. 1 Students using PDAs in the Dental Clinic

Why wireless networking?

Networked PDAs offer a portfolio of mobile learning and clinical support options such as the ability to download, upload and view and interact with a variety of learning in the form of digital multimedia (notes, text, images, diagrams, video, animation, photos, sound). One medical clinical user even states: 'It is difficult to escape the feeling that handheld computers were designed with clinical practice in mind'.[8] PDAs can also offer internet access, email, SMS (Short Messaging Service), address books, memos, calendar, calculator, scheduler and, increasingly, accurate hand-written note-taking ability along with note-sharing facilities.[9] There are an increasing number of specialised services offering downloadable information in PDA-viewable format. Software developers are constantly upgrading PDA-based applications. Connected via dedicated wireless networks or via the internet, PDAs offer many potential benefits for information collection, collation and collaboration.[10,11]

PDAs in teaching and learning

Several studies have evaluated the use of PDAs as both clinical and learning tools. A US-based study found that 50% of participating doctors became 'routine' PDA users and 83% regularly used them for 'niche' uses such as looking up references online.[12] One study evaluating how PDAs can be used for reading found that their portability allowed students to adopt reading habits based around convenience: *'I wanted to study and then realised that the information was in my pocket'*.[13] Convenience and compatibility with standard PCs and laptops was also popular; notes taken on a PDA could be incorporated into more extensive documents at home.[14] Depending on past experience, students adapted the functionality offered by the PDA, modifying data input methods in ways they found easy to manage.[15]

Digital means of accessing and storing current course materials via a VLE and background information (via the internet, for example) are popular with students.[16] Database-linked systems that support shared note-taking ability across a student group are also being evaluated.[9] Such systems allow students to access and 'reuse' both notes and materials provided by a lecturer, and if individual students so permit, their own notes as they are taken, so saving time and facilitating group working.

Data security

Data protection and security issues are ubiquitous in the IT sector; and specific concerns relating to the vulnerability of wireless networks in the business sector have led to an increased developer focus on network security. Several studies of PDA use in a medical clinical setting demonstrate that security, if addressed correctly, is adequate.[8] The National Programme for IT (NPfIT) in UK reviewed the implementation of an electronic patient record for healthcare including dentistry.[17] Academic and NHS networks do not currently communicate with each other except at the highest levels of server administration. In dental schools, as in continuing professional development (CPD), portfolios of patient's treated are valuable educational assets, having secure wireless access to such systems, using patient identifiers, rather than details, is therefore educationally desirable. Concern about privacy will be an ongoing debate, but one that needs to be addressed as far as reasonably possible.[18]

MATERIALS AND METHODS

This study investigated students' use of wireless networked PDAs (Toshiba Pocket PC E570 – The PDA onboard memory consists of 32MB CMOS Flash Rom and 64MB SDRAM) to access their VLE during sessions in the Primary Dental Care clinic (which emulates general dental practice) and for other programme tasks outside of the Dental Institute (Fig. 1). Students are trained in groups of 12, and one group of Year 4 students was selected at random. A simple cross-over designed trial enabled six students from the selected training group of 12 to use PDAs for the first six weeks of the 12-week trial. At the

halfway point, the PDAs were switched to the remaining six students for the final six weeks to ensure that all students in the group had the opportunity to use the technology and to create control groups. An initial training session and online support material ensured that all students had the basic prerequisites to use the devices.

A pre-trial questionnaire (Appendix 1) ascertained the computer expertise and expectations of the students and gave them choices of teaching content. During the trial, a structured learning experience was created for the students, based around a set of week-by-week instructions given to each student in handout form. Throughout the trial a lecturer was on hand to answer any questions. The WebCT (Web Course Tools) platform provided the students' access to the educational content of the trial. A selection of appropriate teaching resources was made available via the WebCT resource area including the learning resource choices made by the students (Table 1).

These WebCT resources were printable or downloadable, and the WebCT interface enabled students to send emails, post notes to a bulletin board for sharing with staff/student forums and enter personal or clinical data via the PDA. A database to record student activity, administer the online questionnaires and a logbook were created within the environment.

Table 1 Percentage of course pages visited

Format	Topic	Percentage of hits
Text	How to interpret a radiographic film	19.5
PDF	Surgical instruments and their use	16.9
JPG (image file)	Image library	14.3
Flash (animation)	Basic Life Support	11.7
HTML (webpage)	Instruction pages for PDA and trial	29.8
URL (website)	Online journals	7.8

The educational evaluation used both the pre-trial questionnaire (Appendix 1) and the post-trial questionnaires (Appendix 2), and focus group interviews. The post-trial questionnaire reviewed operational and technical features, educational and personal uses of the PDAs. The results were analysed using qualitative methodology. The use of the VLE to access multiple media training material (including texts, images and webcasts) was monitored using tools provided within the WebCT platform, for example student tracking and access to course pages. Logs of PDA use, problems and solutions were recorded online.

The competence of the students in using PDAs was assessed through observations of using the devices in the clinics and from data compiled from the pre- and post-trial questionnaire results.

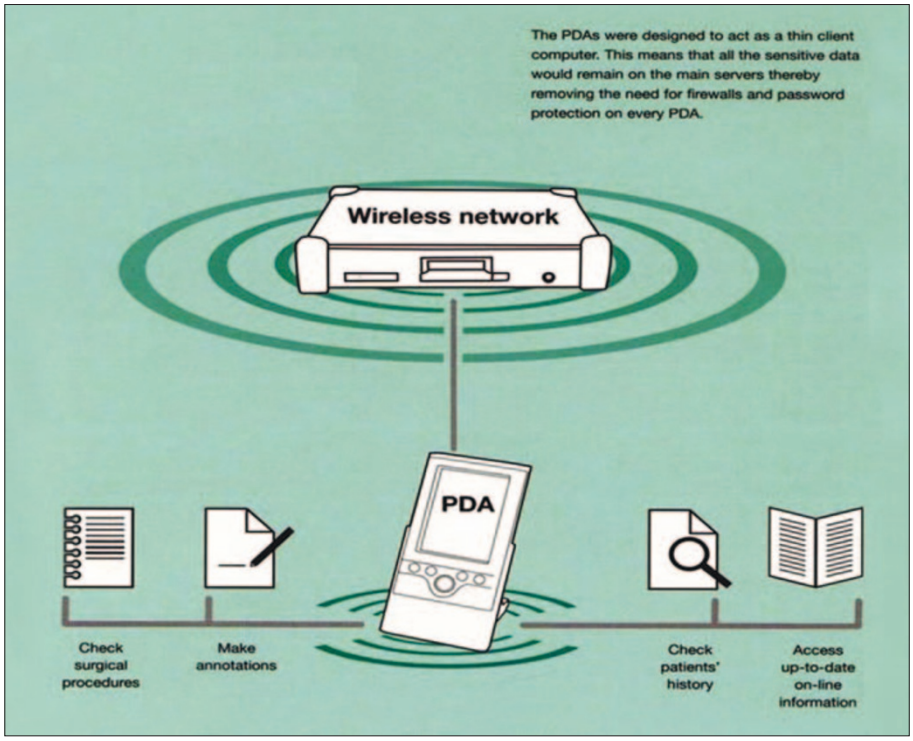

Fig. 2 Wireless network solution

Technical evaluation

A secure standards based wireless network was set up and tested to enable the use of six networked PDAs in a large dental clinic (Fig. 2, Table 2).

Due to the complicated nature of the programs and installation that would have been required, an instant messaging facility based on the Java programming language was excluded from the project. This would have enabled students to communicate in real time with lecturers and each other (in a similar manner to other web messaging programs such as MSN [Microsoft Network] messenger).

RESULTS

Technical evaluation

Network coverage was found to be satisfactory throughout the Primary Care clinic. However, it was noted that wireless network data transmission could be negatively affected by walls and flooring unless network boosters are installed. Assigning individual IP addresses to each PDA also facilitated the complete monitoring of users connecting to the network. The use of the WebCT online teaching environment allowed adequate monitoring of PDA access to, and delivery of, teaching materials. It was found that the trial PDAs were unable to cope with commonly used web page 'pop-up' windows, so web pages were modified in order to display 'pop-up' data as separate pages. The trial PDAs pre-installed media player, using Pocket PC, did not initially play online movies – a problem that was easily resolved by installing the latest software patch. Once functioning, videos did experience 'frame skips'. The cause of this was unclear, although it could have been due to the trial PDAs' internal processing. A small application, Flash Player, was provided to allow animations or small graphical presentations to be accessed.

The main problem the students experienced was the limited battery life of the supplied PDAs (four hours) and insufficient memory to store large files. However, newer PDAs now have much longer lives and larger memories.

The log diaries on the Bulletin Board reported that: 'Even X, the least co-operative student - was given instructions to access network, complete the questionnaire and check email. No problems.'

For home use one log diary reported: 'Two students using several functions and integrating the PDA into their lives. 1 hr per night. 2 students are just getting to grips using the PDA, both have finished the tasks set (basic functions and inputting name)- 30 mins per night. 1 student has not opened the box. Initial impressions are good. Problems with hand writing recognition and battery life.'

Educational evaluation

The trial groups successfully completed pre- and post-trial questionnaires online by using the quiz facility of WebCT. Eight students had used PDAs before and four had not. Three students perceived that they were advanced ICT users, seven intermediate and two were beginners. However, the results showed that the students developed both confidence and competence in a short period of time, with support from the research officer and supporting instructional material. The less experienced users felt that their ICT skills improved by using the devices. There were no differences of more than one vote seen between the two groups of users. The results were therefore compiled from both groups to increase the sample size for further analysis.

Table 2 Security features of wireless network

- Mapping the area of transmission to ensure networks were not accessible outside of the clinical area by appropriate positioning of the distributing hubs
- Ensuring all data were encrypted (encoded) during transmission
- Using the concept that the PDA was acting as a 'thin client', the PDA could only access secure data when in range of the hub. A 'thin client' is defined as a peripheral device that accesses applications and data centrally on a server, but does not store them
- Point to point connectivity using each PDA's unique MAC (Media Access Control) number so that only authorised devices were able to connect to the network
- Similarly allocation of an IP (Internet Protocol) number to each PDA made it uniquely identifiable in the network
- During the trial the network was disabled at night

Table 3 Educational resources on WebCT

- Text-based documents featuring lecture notes
- Illustrative images and textual extracts
- Powerpoint presentations on chosen subject areas
- Portable file formatted (PDF) documents
- Instructional images

WebCT access

Both groups of students accessed the programmes within WebCT frequently, and several students used the PDA for diary-keeping and notation exercises. Such usage depended on the computer literacy of the student rather than the group they were in.

The average number of logins to WebCT per participant was 18 and the average number of content pages visited was 12 (range 3-25) spending a mean time of 11 minutes 2 seconds per page (Table 3).

Although 91.7% wanted the PDA as part of their dental kit, and 75% of students strongly agreed or agreed that they should own a PDA, 16.7% did not want to own one. However, 50% were prepared to pay between £150 and £200 for such a device. They showed an overall 'good' to 'excellent' rating, regardless of crossover, for the use of the various features of WebCT accessible on the PDA, and to the use of diaries (calendars) (Fig. 3).

Students appreciated the opportunity to access all forms of media via the PDA. Lecture notes and videos (webcasts) were noted as the most useful media.

Focus group session

The students were also interviewed in a focus group session and were asked about their abilities when using the PDAs. The responses showed that the majority found them easy to use. There were specific PDA features that were very valuable, while others were less frequently used. For example, the students who already had expertise in using PDAs were able to make use of the video and animation resources and reported using them regularly for their own personal as well as educational use. Two of the students who were less skilled in using ICT generally reported using the PDAs in a more limited way. There appeared to be no problems with reading from or writing on a smaller sized screen. They liked the convenient and portable size and preferred these rather than laptops in the clinics. They expressed the wish to be able to connect to their own records and to those of the patients, although they realised there were confidentiality issues. The PDA was seen as a positive asset in reducing the 'queuing' time to use the current PC based system of recording patient activity.

DISCUSSION

Technical evaluation

A secure wireless connected network enabled students to connect to central teaching servers to access their virtual learning environment, WebCT, from which they were able to view a series of media formats. This meant no trailing wires in the clinics, no keyboards and mice with potential infection control issues.

Although battery life and memory problems were the features most disliked, these have been largely overcome by the new generation of PDAs. The advantages of the thin client (Table 2) approach was that access to content on the server was unrestricted, and access to up-to-date information was assured. Such an approach, using the PDA mainly as an access and delivery device, also meant that there was no loss of content due to deletion, technical crashes or battery failure.

The instant, always-on nature of PDA connectivity was popular with students, as opposed to laptops that take several minutes to boot up. Even the most challenging student was able to use the equipment with support.

Educational evaluation

As found in other studies both students and lecturers enjoy the interactive potential of PDAs, especially class voting, quiz-based self-tests and online questionnaires for students.[12] Students also find PDAs useful for recording and accessing data in clinical settings. Studies have also focused on the potential for using PDAs and other mobile devices to fill 'niche time' that might not otherwise have been profitably used.[19]

In the home setting, the recreational

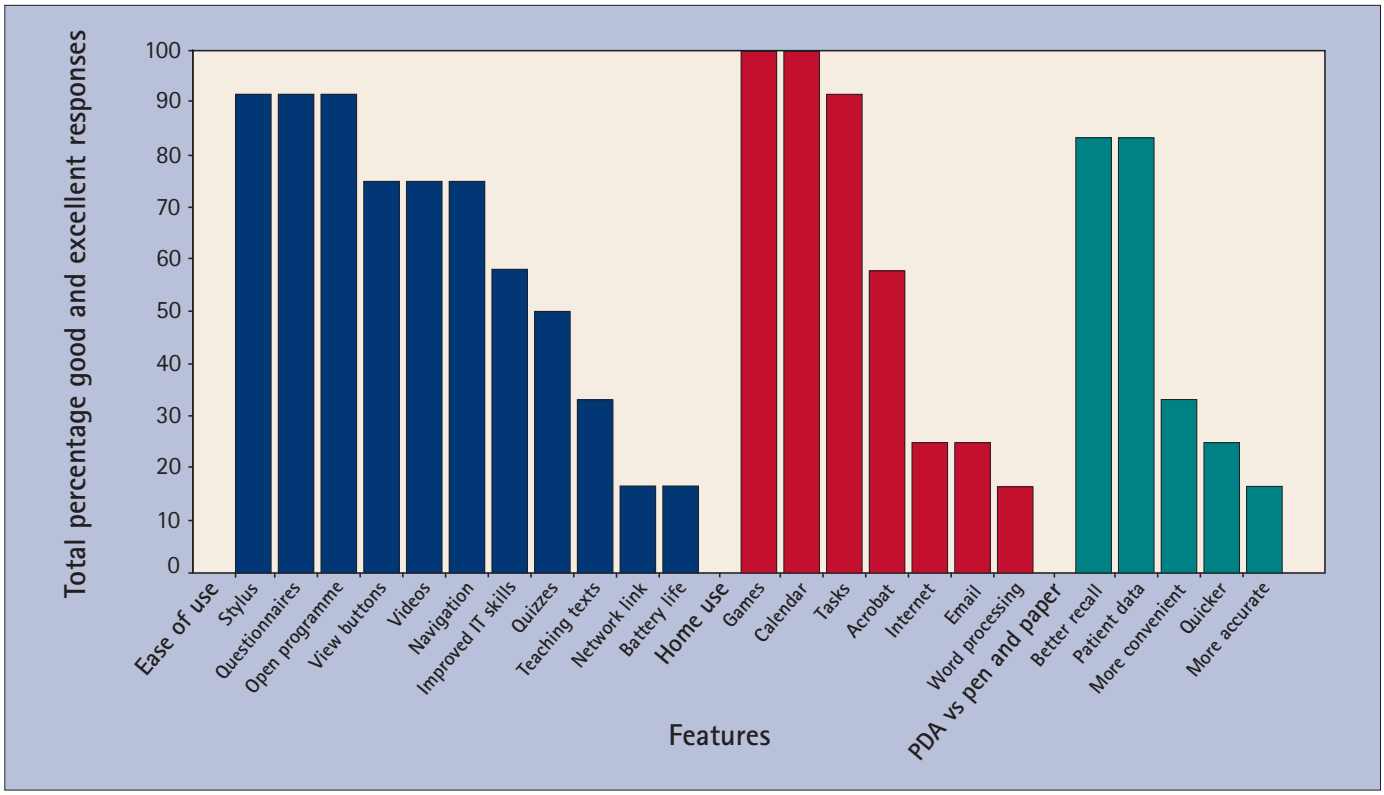

Fig. 3 Total responses from both user groups for 'Good or Excellent' PDA features

uses of PDAs also became evident with voting in favour of gaming, music downloads, calendars and even alarms. Students saw the PDA as a 'one stop shop' for all the requirements of giving and receiving information, evidenced by the positive response to their use in questionnaires and interviews, and reluctance to give up the devices. As 100% of students enjoyed gaming using the PDAs at home, there are clear indications that appropriate educational games such as crosswords should be made available in PDA format.

The most significant disadvantage was that not all the lecturers provided teaching materials online. The range of ICT resources caused confusion in both staff and students about the ongoing integration of technology and such concerns clashed with their growing expectations of an integrated ICT-based learning environment.

Many studies have also noted the factors limiting PDA usability; however, continual technological advances are rapidly addressing these issues. As technologies mature and improve and costs begin to come down, it seems likely that PDAs have a very promising future as both study and clinical support tools.

A follow up trial has now commenced with 40 Year 2 undergraduate students owning PDAs donated by the King's College London Alumni Association (KCLA) from Year 2 with no time limit. It is hoped that by 2008 all dental undergraduates will have the opportunity to use this portable technology in the College and at home.

Relevance to the GDP

This pilot trial has shown that the future generation of practitioners will have the desire and capability to use mobile computing in the clinical and home settings. Such portable technology can be used to access CPD, to manage their personal time, and access information sources for education and recreation. This would be particularly useful at the chairside for accessing resources eg electronic BNF (British National Formulary) and for saving time in maintaining electronic records.

A wireless network with the 'thin client' capability and other security features points towards the future capability of viewing patient records with full respect for confidentiality. The ultimate portable mobile device with 3G capabilities will allow ever more instant communications and for those who embrace the challenge of this cultural change, a new world of practice, patient and personal management can emerge.

For the practitioner, the choice of technology can be daunting. New devices appear almost every month. The role of the fashionable Apple iPod™ as a functional, yet easy to use, mobile device of the future has even been suggested.[20] Part I of this article described choices of PDA features; this study describes the use of PDAs in a secure wireless networked clinical environment. To set up such networking in the surgery or at home, a wireless router, acting as a hub, connects peripheral wireless enabled devices (such as the PDA) to the main computer. To connect to the internet a *broadband* wireless router can be used which acts as a modem when connected to the broadband source. Such a router may also have an integral firewall for added protection. Alternatively, the smartphone (PDA plus mobile phone) can offer mobile connectivity to the internet together with personal management features, and some also have wireless capabilities - the preference depending on the needs of the individual practitioner.

CONCLUSIONS

This pilot study demonstrated both technological and educational aspects of using PDAs in a clinical dental environment. Security issues were paramount but the risk involved with data security still

remains a concern, especially where confidential data are being accessed. However, this limited trial did demonstrate local security measures being employed to connect the PDAs to college networks and servers via a wireless network.

The ergonomics of the devices in such a network inevitably reduce the crevices and cracks present in standard PC networking equipment, but further work would need to be done to confirm any infection control advantage.

All of the students found PDAs to be useful in support of their learning, and expressed regret that they were not able to keep them longer. They all agreed that it would be very useful for their learning if the entire undergraduate cohort could be provided with PDAs for the length of their course. Specific benefits included:

- Being able to keep notes of their lectures and individual study
- Being able to keep a diary of their commitments including their undergraduate timetable
- Having online access to support materials, particularly video materials.

This trial gave an insight into the secure use of PDAs and an understanding of the barriers and difficulties encountered by the users (undergraduate dental students) in a professional environment where the learners were mobile and where part of the management of that learning was distributed. The potential of PDAs and mobile technologies in teaching and learning in dentistry is beginning to emerge.

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Appendix 1 Pre-Trial Questionnaire

A) The following sections may be placed on to the PDAs. How useful do you think they would be?
Student Records, X-rays, BNF, Course Notes, Technique videos, Patient notes
Choice of: *Excellent/Good/Don't know/Poor/Very poor*

B) Which clinical technique videos would you find most useful?
Open Question

C) What is your level of computer experience?
Choice of: *Advanced/Intermediate/Beginner*

D) Have you ever used a PDA? Choice of: *Yes/ No*

E) What specific benefits do you perceive the PDA will bring?
Please tick all that apply
Convenient, Portable, Easy to use, Customisable, Records my progress, Saves time in clinic, Helps with revision, Keeps in contact with tutors, Secure

Appendix 2 PDA Post Trial Questionnaire

Section A. Operational/Technical

Choices of: *Very easy/easy/no opinion/difficult/very difficult/not used/ did not understand how to use*

1. Familiarisation: How easy was it to get used to using the following features of the PDA
a. Use of stylus, to write, type and block text
b. The use of the PDA interface
c. Using the view button to change the appearance of the screen and other tools was
d. Opening and closing programmes
e. Navigate between programmes

2. How easy was using the PDA on the clinic for:
a. Connecting to the network
b. Inputting data using the Dental Activity Capture system (DACS)
c. Accessing the internet
d. Accessing teaching resources on WebCT
e. Viewing videos and webcasts
f. Completing quizzes on WebCT
g. Completing questionnaires on WebCT

3. How easy was it to use the PDA at home for:
a. Word processing
b. Spread sheets
c. Calendar
d. Listing your tasks
e. Acrobat Reader
f. Email
g. The internet
h. Games
i. Other features: Please specify what was used and how easy it was:
Free text box

4. The battery life was satisfactory:
Strongly agree/agree/no opinion/disagree/strongly disagree/did not use/ did not understand how to use

5. What were the best features of the PDA?
Free text box

6. What were the worse features of the PDA
Free text box

Section B. Personal Use/Educational

Choices of: *Strongly agree/agree/no opinion/disagree/strongly disagree/ did not use/did not understand how to use*

7. Indicate how easy was using the PDA at home and college compared to writing with pen and paper
a. More accurate
b. More convenient
c. Quicker to use
d. Better recall of data
e. It was an easier and better way to enter the patient's data
f. I preferred using this method to writing patient's notes

8. What were the main benefits of using the PDA?
a. Convenient
b. Portable
c. Ease of use
d. Customisable
e. Saves time on clinic
f. Helps with revision
g. Helps my progress on the course
h. Helps my general ICT skills

9. Ownership
a. I would like to have a PDA as part of my student kit
b. I would prefer to have a PDA loaned and then hand it back if it were recommended for the course
c. I would be prepared to pay for a reasonably priced PDA (150-200) if they were recommended for the course
d. I would be prepared to pay for part of the cost of a PDA if they were recommended for the course

10. How much help did you get from staff or fellow students to use the PDA?
a. I needed help from staff
b. I needed help from my fellow students

11. How could the PDA be improved?
Free text box

12. Feel free to add any other comments?
Free text box

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