Original article

Evaluation of a mobile learning organiser for university students

Dan Corlett, Mike Sharples, Susan Bull & Tony Chan
Educational Technology Research Group, Department of Electronic, Electrical and Computer Engineering, University of Birmingham, Edgbaston, Birmingham, UK

Abstract This paper describes a 10-month trial of a mobile learning organiser, developed for use by university students. Implemented on a wireless-enabled Pocket PC hand-held computer, the organiser makes use of existing mobile applications as well as tools designed specifically for students to manage their learning. The trial set out to identify the most-used tools for such a learning device and their patterns and problems of usage. The primary uses of the organiser were communication, time-management and access to content. No single application took precedence. The results from an analysis of questionnaire surveys and focus groups indicate that there was a demand for institutional support of mobile learning, in particular to provide course content and timetabling information. Wireless connectivity was crucial to the usefulness of the organiser. Usability issues relating to the hardware and software had considerable impact on the students' usage and satisfaction with the system.

Keywords hand-held computer, learning organiser, mobile learning, undergraduate student

Introduction

Many students embarking on a University course bring with them one or more mobile computing devices, including smart phones, personal digital assistants (PDAs) and laptop or tablet computers. The software on these devices is designed primarily to support the world of office work. Typical applications include time management, communication and productivity tools. While these are of some use to students, they are not designed specifically to support their activities, such as attending lectures, reading course content, revising for exams and meeting course deadlines.

As these hand-held computers and smart phones become more widely used there is an opportunity to harness them to benefit learning, as well as to provide appropriate institutional support for their use. In the shift from mass teaching to support of personal learning, it is also the responsibility of educators to ensure that students have the relevant skills and environments to succeed as self-directed learners.

Focusing on PDAs, the study described below has investigated whether students would find a hand-held computer useful for supporting their learning, and in particular whether a specially designed, integrated learning organiser would be more suitable for supporting learning than the existing set of 'mobile office' tools, such as a digital calendar, contacts list and to-do list. A mobile learning organiser has been developed at the University of Birmingham (Holme & Sharples 2002) and was evaluated as part of this study.

A group of 17 MSc students at the University of Birmingham were loaned wireless PDAs. The department in which the students were studying has wireless coverage throughout its five storey building. In addition to running standard Pocket PC applications, the PDAs provided a mobile learning organiser

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Correspondence: Dan Corlett, Educational Technology Research Group, Electronic, Electrical and Computer Engineering, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK.
E-mail: d.j.corlett@bham.ac.uk

which comprises an integrated suite of tools for students to access course material, view their timetables, communicate via e-mail and instant messaging and organise ideas and notes. The tools were based on the Pocket outlook personal information Manager (PIM), with a custom-designed interface to present the information in a form that matches the structure of student learning. For example, the calendar was presented as a series of teaching slots corresponding to the standard University timetable.

Two concept mapping tools were also evaluated. Map-It! (Chan & Sharples 2002) formed part of the original integrated organiser and concise concept mapper (CCM) (Rudman & Sharples 2002) is a standalone tool.

The trial lasted for 10 months during 1 academic year. The aims of the study were to investigate:

- the usability of the hardware and software;
- the perceived usefulness of the PDA as a learning organiser;
- the perceived impact of the tools on learning;
- reported patterns of usage;
- whether students installed and used additional tools to those provided for them at the start;
- the students' attitudes to the PDAs and their provided tools.

The paper concludes with some implications for the design of future learning organiser tools for students.

Method

Setting

The study was carried out during the academic session 2002/2003 in the Department of Electronic, Electrical and Computer Engineering at the University of Birmingham. Seventeen students on the Human Centred Systems MSc course were recruited to the trial. One student dropped out after a few weeks, but another joined about half way through.

The trial began with a training session to familiarise the students with the hardware and software.

Equipment and software

Each participant in the study was loaned a Compaq iPAQ 3760 hand-held computer, running Pocket PC 2002, with 64 MB memory. Each device was supplied with an expansion sleeve and an 802.11b wireless network card, able to transmit data at up to 11 Mb/s. When attached, the sleeve and card roughly double both the size and weight of the device. The mobile learning organiser comprised:

- a modified 'Today Screen', with a timetable bar showing the times of classes and other appointments (Fig. 1);
- a Timetable Manager with downloaded course timetables and deadlines, which allows the user to see the teaching events for each day (Fig. 2);
- a Course Manager, organised by course module (Fig. 3);
- course material in Microsoft Reader and PowerPoint formats;
- a Communication Centre for e-mail, internet messenger and contacts;
- Map-It!, a concept mapping tool to create a visual map of notes and documents (Fig. 4).

The Today Screen and Timetable Manager use the Microsoft Calendar to store the events, so students

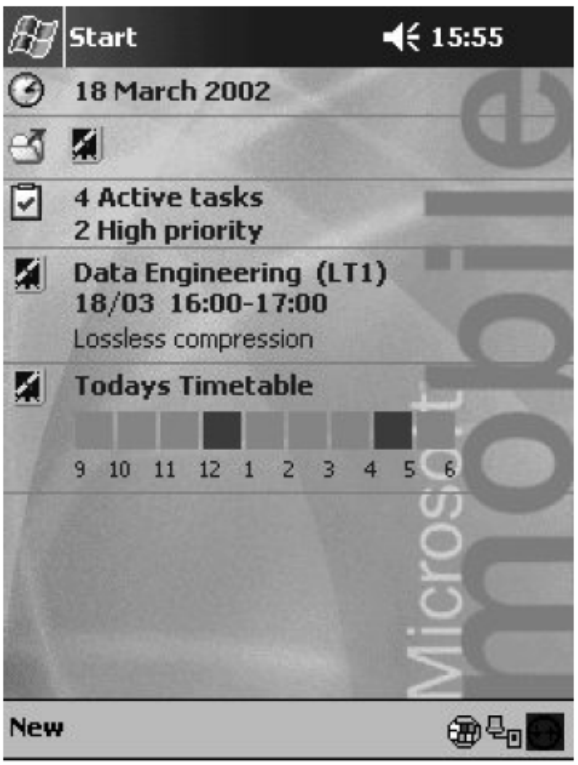

Fig. 1 Modified 'Today Screen'.

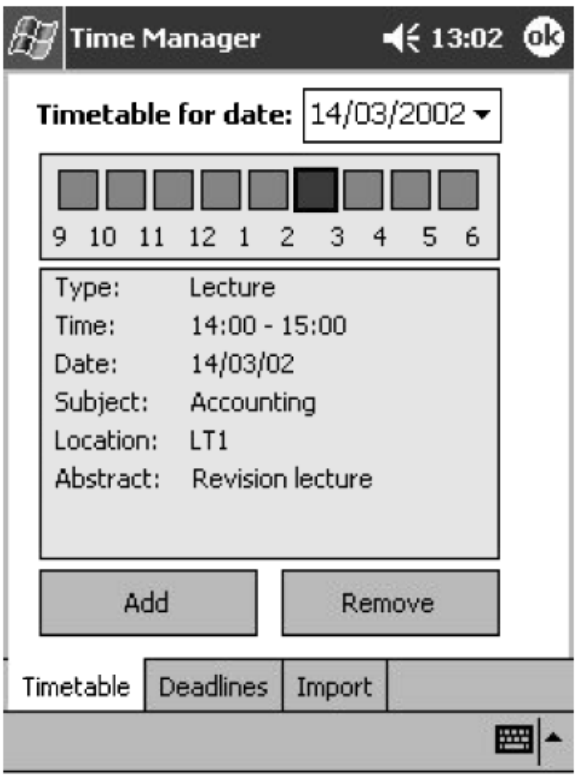

Fig. 2 Timetable manager.

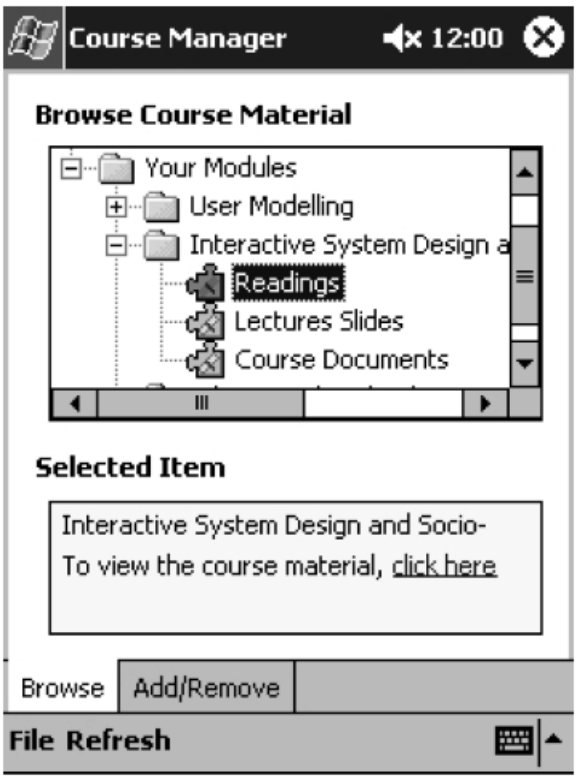

Fig. 3 Course manager.

have the choice of viewing their scheduled classes within the learning organiser, or on the standard Calendar. Later, a second concept mapping tool, CCM, was provided to the students (Fig. 5).

The choice of software tools was pragmatic. Given the limited time for software development, the organiser and content elements were based on the standard Pocket PC suite, which had the advantage of presenting a familiar Microsoft look and feel. Timetabling was assumed to be an important issue for the target student group owing to the nature of their course, which is taught in short, intensive modules and where the detailed schedule for each module is often not publicised until shortly before it runs. Content for each module was packaged in PowerPoint and Reader formats. Both formats were optimised for the small screen and allow students to annotate, save and share their notes.

Both concept mapping tools were designed for the Pocket PC with a stylus input, and both assist information recording through visual semantic association. However, they differ significantly in operation. Map-It! uses a logical tree structure that the user navigates by clicking on an outer node which brings it to the centre, displaying the related topics. Clicking on the centre node displays any document associated with it. The user adds a new node by selecting a document from file. CCM provides a free-form concept map with interaction by pen gestures, dragging and scrolling the map as necessary. Search and zoom facilities reduce usability problems inherent in working with large maps on a small screen.

The concept-mapping applications were chosen because of the evidence that tools for desktop computers, such as SemNet®, can aid studying and note-taking (Gorodetsky & Fisher 1996). Despite the obvious limitation of screen size, it was considered that the advantage of being able to make maps wherever learning is taking place may be of benefit. A comparative study of the concept map usage (Sharples *et al*. 2004) shows differing benefits of each application with respect to the students' learning, with CCM best designed for note-taking and Map-It! for exploration of pre-prepared content.

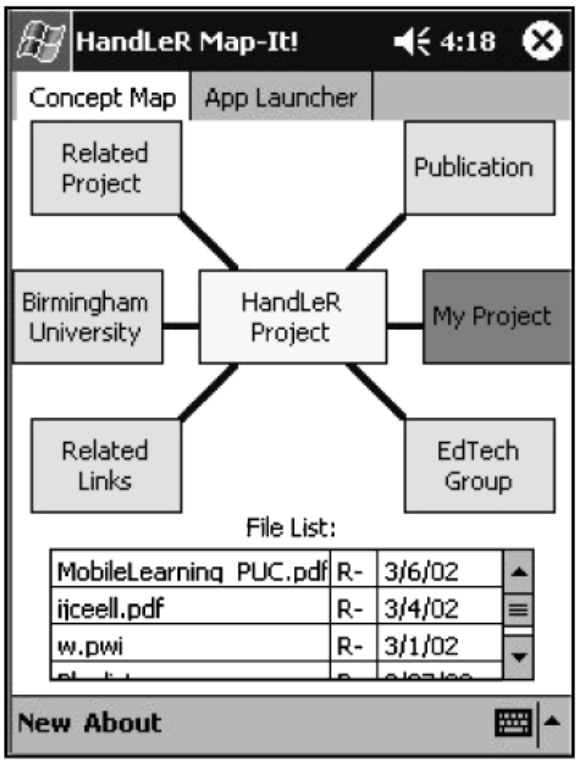

Fig. 4 Map-It! concept-mapping tool.

Throughout the year, students were also encouraged to use their PDAs for their leisure and entertainment and to add any software they wished.

Methodology

In order to evaluate the mobile learning organiser in a realistic setting, students were permitted to use their PDAs as they wished. Results were collected by three methods, as listed below.

- Questionnaires were administered at 1, 4, 16 weeks, and 10 months.
- Focus groups were held to follow on from each of the questionnaires.
- The students kept logbooks for 6 weeks.

Each of these methods was designed to reveal:

- students' attitudes to the technology;
- students' attitudes towards the learning organiser;
- patterns of usage of the various applications (including any they had downloaded themselves);
- patterns of usage of the technology, particularly with respect to wireless connectivity;

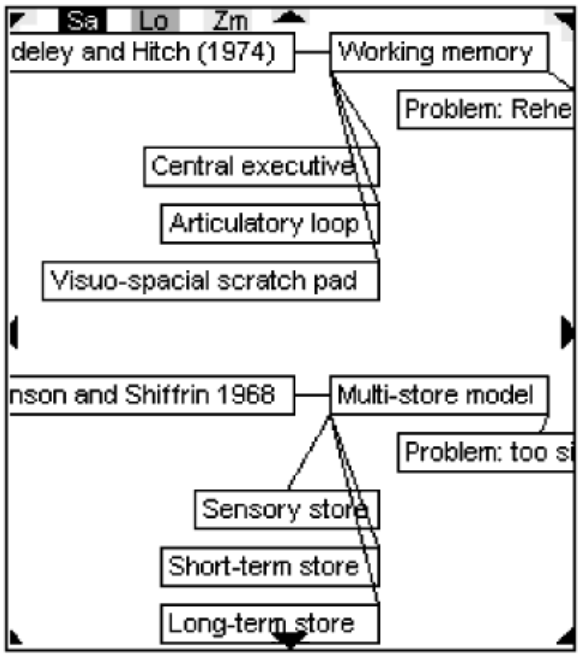

Fig. 5 Concise concept mapper.

- usability issues;
- issues relating to institutional support for mobile learning devices.

Results and discussion

This paper draws largely upon the results collected at the final questionnaire and focus group, although some reference will be made to the earlier findings, particularly with respect to changes in usage patterns and attitudes during the course of the trial.

Usability of the hardware

Data on usability came from the final survey, in particular from questions that asked 'What software, services or hardware would improve the usefulness of the iPAQs?' and 'Were there times you would have preferred the use of a laptop computer to a Pocket PC? If yes, briefly describe one scenario.' The students were also asked to describe usability problems during the final focus group. The most reported issues related to the usability of the hardware, including weight and screen size, the limited memory and the battery life.

The problems of limited memory increased during the year as students continued to download content, such as games and music, without wishing to remove existing materials. As the participants were required to

return the PDAs at the end of the year, they were not willing to invest in additional memory modules.

Although a recharged battery would generally last for 1 day, if left uncharged for a number of days, the units lose all data and programs added by the user since these are stored in volatile memory. On a few occasions (generally during the vacations), students left their devices disconnected from the mains for longer than a week, and as a result had to reinstall all their software and data.

The backup process (part of the standard synchronisation software) was reported by some students as being slow and unreliable. Thus, participants backed up infrequently, compounding the difficulties experienced when the memory was erased.

Screen width, general crashes and applications not fully closing (and therefore slowing the device unnecessarily) were also cited as annoyances about the device. Survey responses indicated that entering text was cumbersome, and in the final focus group the students indicated that a foldaway keyboard could offer a big improvement for entering large amounts of text.

Usability of the mobile learning organiser software

The main software usability issues identified in the questionnaire were are as follows:

- the mobile learning organiser software was slow to respond. In particular, the Timetable Manager was slower and less easy to use than the Outlook Calendar.
- Content and timetable information would have been easier to download had it been deployed online rather than through the synchronisation tool.
- Much of the content made available by lecturing staff over the web was not optimised for Pocket Explorer, making it difficult to read.
- The concept mapping tools were difficult to use without further instruction.
- Participants were reluctant to use the concept mapping tools, in part because the content was not stored in a format that could easily be transferred to other applications, such as Word.

Perceived usefulness of the PDA as a learning organiser

No single tool stood out as being likely to revolutionise the students' learning or personal organisation. Table 1 shows the perceived usefulness of the various tools at three stages of the trial. Communications tools, the web browser and the timetabling features were consistently among the most useful. The perceived usefulness of the course content and the concept mapper decreased over time. It should be noted, however, that the students were provided with less content and materials later in the course, and at the time of the 10-month survey students were concentrating on project work as the taught component of the course had been completed.

Perceived impact of the tools on learning

Participants were asked in the survey to name the tools that made the greatest impact on their learning, personal organisation and entertainment. The freeform answers were collected under generic headings. Table 2 lists each tool mentioned as having the greatest impact, with the number of students who mentioned it. It indicates that for learning, course materials are regarded as having most impact despite the lower perceived overall usefulness. Despite the wireless connectivity in the department, and the perceived usefulness, e-mail did not feature highly as a benefit to learning. Web browsing was a useful learning support for some students, and the calendar and mobile learning organiser timetable and deadlines were useful for personal organisation. The Media Player had the greatest impact in the entertainment category. Concept mapping was not considered of greatest importance by anyone in any category.

Reported patterns of use

The study aimed to find out where and when students used the device and its constituent tools. The ques-

Table 1. Perceived usefulness of tools, showing mean of a five point scale (Not Useful, Probably Not Useful, Possibly Useful, Useful, Very Useful) at 4 weeks ($n = 17$), 16 weeks ($n = 14$) and 10 months ($n = 17$)

	4 weeks	16 weeks	10 months
Timetable	3.7	3.6	3.9
Web browser	3.8	3.8	3.6
Instant messaging	3.8	3.5	3.4
E-mail	3.8	4.0	3.4
Course materials	3.7	3.1	3.1
Supplementary materials	3.6	2.9	2.7
Concept mapper	2.6	2.5	2.1

Table 2. Perceived impact of tools on learning, personal organisation and entertainment

Learning	Personal organization	Entertainment
Course materials (6)	Timetable and deadlines (6)	Media player (7)
Browser (3)	Calendar (5)	Games (3)
Timetable and deadlines (2)	Writing/note taking (2)	Messenger (2)
Writing/note taking (1)	E-mail (2)	Browser (1)
Calendar (1)	Task manager (1)	Writing/note taking (1)
		Reader (1)

Figures in parentheses indicate the number of students naming the tool as having greatest impact. Not all participants answered all three questions.

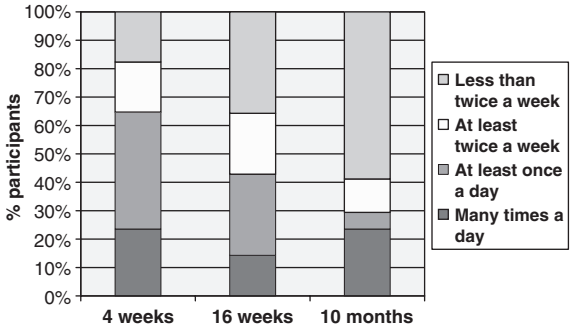

Fig. 6 Frequency of use of the personal digital assistant through the course of the trial.

tionnaire asked the students to indicate how often they had used the PDA during the previous 2 weeks. As can be seen in Fig. 6, use of the PDAs overall declined over time. However, the percentage of participants using the devices many times per day stayed much the same, at around 15–25%. Starting with a more even spread, usage became more polarised between some students who used them many times a day and a larger number using them very infrequently.

The logbook study that took place during the first 6 weeks had revealed that home, the department and elsewhere on campus were the most common locations of use (Bull 2003). Participants were therefore asked in the surveys how frequently they used their PDAs in each of these three locations (on a four-part scale of Frequently, Sometimes, Rarely, Never) and whether this was for MSc-related work or other activities. Given that we are aiming to support the mobile learner, the survey also asked whether they used their device while travelling, a further 'location' in which some students used their PDA during the logbook study. Table 3 shows the number of students reporting that they had used their PDA frequently, for each of these locations during the study. At home and in the department were the most popular locations early in the study for both MSc and unrelated activities. For unrelated activities, 'travelling' gained in popularity. It is worth noting again that more project work is carried out towards the end of the course, so it is likely that students will spend less time in the department. However, this result may also suggest that the students were finding more uses for the devices and beginning to see their value as mobile tools.

Table 3. Number of students reporting that they had used their PDA frequently, in four locations for MSc-related work (and in parentheses, for other activities)

	4 weeks	16 weeks	10 months
Home	4 (7)	0 (3)	3 (4)
Department	5 (2)	1 (2)	3 (2)
University (elsewhere)	0 (1)	0 (0)	0 (1)
Travelling	0 (2)	1 (2)	1 (4)

PDA, personal digital assistant.

Students were invited to describe their patterns of use through a question that asked 'If there are any common patterns to your iPAQ use, please state them below (for example, frequently read and send e-mail in EECE common room)'. Some interesting observations include the following:

- Although e-mail is synchronised to the device and can be read anywhere, students only tended to use e-mail when in an area covered by the wireless network.
- E-mail and instant messaging were frequently mentioned together, as if they were complementary tasks.
- Participants used the calendar and timetabling in all locations, as they had need. For some, the PDA became a replacement for a traditional diary.
- In the week 4 survey, there were many references to using the device for listening to music and playing games. By week 16, these activities were less frequent.

- A few students reported regularly reading course materials, offline web content and e-books when at home or in their dormitories. This was surprising, since the final focus group revealed that all of the participants had their own desktop or laptop computers in their apartments.
- For a few students, this was the first time they had kept their personal organisation information in an electronic format. Among those, some only made use of this information through the PDA, even though it was synchronised to a laptop or desktop.

A separate question on how students' use of the PDAs had changed over the course of the year did not yield any noticeable trends. Some students attempted to use it for many activities in the early stages, before accepting that some tasks were better done on a standard PC. Others, who were sceptical at first, later became frequent users of the devices. Either way, after 10 months, students had evaluated the capabilities of the PDAs, adapted them to their needs and settled into a personal pattern of use.

Other tools that students chose to use

Participants were encouraged to use the devices for their own personal activities and to install any software they wished. A number of them chose to develop software for PDAs as part of their project work.

Not surprisingly, among the most popular downloads were various games and an additional media player. Several different PIM applications were tried as alternatives to the ones included with Pocket PC or the integrated learning organiser. Other installations included a money manager and a photo album.

Two students used Microsoft Portrait (a Pocket PC equivalent of NetMeeting). One of these students reported to have used Portrait to contact his family living on another continent. He received audio and video of them, and was able to speak to them, using the PDA as a mobile internet phone.

Several of the students installed Chinese character support for their communication with one another and their friends and family at home. In the focus group they requested that this should be included as standard in any later projects, since finding and installing a suitable package had taken some time to do.

Only two online services were subscribed to by any students. Three students used AvantGo on a regular basis to synchronize Web content including news.

In total, just 18 pieces of additional software were installed, by eight students. This result was explored further in the final focus group, and two reasons became apparent:

- Most students saw all the value of the PDAs being either in time management or in e-mail/messaging. These were already catered for with the standard software.
- Because the devices had to be returned within the year, participants were reluctant to invest much of their own money or time in personalisation.

Students' attitudes

An attitude survey was conducted as part of the final questionnaire. The questions were designed to assess the students' attitudes to using the PDA as a tool for learning and to aspects of its usability that the earlier surveys had indicated as being important. Students were asked to rate statements on a five-point Likert

Table 4. Mean and standard deviation of responses to a 5 point Likert scale from Strongly Disagree (1) to Strongly Disagree (5)

Statement	Mean	SD
(a) I think the iPAQ has assisted my overall learning process this year.	3.19	0.98
(b) I think I planned better for my learning with the iPAQ than if I had not had it.	3.37	1.31
(c) Having to use the iPAQ hindered my learning	2.31	1.14*
(d) I would have used the iPAQ more had there been fewer technical problems.	3.00	0.89
(e) I found battery life a significant problem	4.06	0.68*
(f) I felt uncomfortable using the iPAQ because I didn't know how to use it.	2.19	0.65*
(g) I felt self-conscious using the iPAQ in public	3.00	1.09
(h) The advantages of having an iPAQ outweighed the drawbacks of taking part in the trial (attending meetings, doing questionnaires etc.).	3.56	0.96*
(i) I have changed the way I plan for learning as a result of using the iPAQ.	3.18	1.17
(j) I have changed the way I take notes as a result of using the iPAQ.	3.06	1.38

Starred items are significant at $P<0.05$. $N=16$.

scale. Table 4 shows the mean and standard deviation of the response to each item, in the range from 1 (Strongly Disagree) to 5 (Strongly Agree). A one-sample *t*-test was performed on each mean, with 3 (No Opinion) as the constant value. Four statements show a significant difference from No Opinion ($P < 0.05$):

- Using the PDA did not *hinder* learning (c), however, neither did it greatly assist (a).
- Battery life was a significant problem (e).
- Students did not feel uncomfortable using the PDA though not knowing how to use it (f).
- The perceived advantages of having a PDA outweighed the disadvantages of taking part in four questionnaires, three focus groups, one training session and keeping a log book for 6 weeks (h).

It was never intended to conduct a quantitative study into the learning gains brought about by using mobile technology. However, is appears from their self-assessment that the technology has not revolutionised or greatly improved their learning. It seems simply that the learning organiser is just *another* resource among many.

A separate question was asked, that assuming students had access to a PC at home and one in the department, would they prefer a laptop or a PDA as their *only* mobile device. The responses were nine to six in favour of a laptop. This is far from the unequivocal preference that could be expected from the quantity and variety of negative issues raised about the PDAs, and the obvious advantages of a fully functioning portable PC. This question was pressed further in the final focus session where students were demonstrated a Tablet PC. Even with a Tablet PC as the alternative, the same proportion of students preferred the PDA. Six of the students claimed there were never any times while using the PDA that they would have preferred the use of a laptop. This could suggest either that the PDAs sufficiently met their mobile needs, or simply that they made judicious choices as to when to use them and so were never disappointed.

Asked in the group interview, nobody felt compelled to buy their own PDA following their course.

Implications for future design

The study has indicated issues of relevance to the design of mobile learning organisers for PDAs. Wireless connectivity and the ability to send e-mails and engage in messaging appear to be essential components. As educational institutions develop their wireless infrastructure, then PDAs could offer students easy access to these facilities across the campus.

The study has shown no clear need for a custom-designed learning organizer, with a separate interface to that of a PIM such as Pocket Outlook. However, there would appear to be a need for tools that enable students to easily find, browse and read course materials, and also to be reminded of course deadlines. Further research and system design studies are needed to discover whether such study management tools could be integrated into a conventional PIM.

Another opportunity is to provide tools that adapt to a student's context and learning needs, based on location data and information from a learner model constructed during interactions (Bull *et al*. 2004).

The usability limitations of PDAs could, in part, be overcome by providing students with pen tablet computers with a longer battery life and larger screen, but at the cost of greater bulk and weight. We are conducting a study in which a cohort of students use pen tablet computers to support their studies.

Summary and conclusion

This study was designed to discover the patterns of use of a mobile learning organiser (wireless Pocket PC with appropriate and useful software installed) when used by students in a wirelessly networked study environment and other locations of their choice.

A few clear modes of use emerged. Students made considerable use of the calendar and timetabling features as well as the communications tools. More use was recorded in their department of study than elsewhere. Study materials were also well used, and participants requested that more content could be delivered in this way.

PDA-optimised content was well used, and there was a clear request from students that more resources be made available in PDA format, including administrative information.

There is no conclusive evidence of the need for a specifically designed suite of tools in addition to those already included in the device, although the time management tools were well received. The concept-mapping tools were not widely adopted. This is not

proof that they are not required or are unhelpful. Rather, at this stage, the evidence simply suggests that the specific tools had usability issues and that students were not well acquainted with the skills of concept mapping. Participants were also concerned that maps could not be easily transferred to other software and devices after their course.

Ownership of the technology is clearly important. While the PDAs are loaned, students are reluctant to invest time and money in personalising and extending them. Despite this, several students were able to see future benefit of the devices as learning aids and invested time as part of their projects in developing software for them. A higher specification of device is also likely to increase use. If students can download more music and other content, PDAs are likely to become a part of their lifestyle.

Only one student made use of the wireless network card in another location (at home and at a train station). As wireless networks become more widespread, the device will become more fully functional in more settings. It is likely that acceptance and patterns of use would change considerably.

The use of PDAs as learning organisers has implications for institutional support of learning. For example, to be effective, teaching materials and websites will need to be designed for display on small screens. Although there is no indication that the mobile learning organisers used in this study greatly altered students' styles or patterns of learning, they did have some impact on the way the students worked, and on the demands placed on their lecturers.

By the end of the study, only 30% of students were using the device every day. Although this constitutes a minority, this figure is sufficiently large to warrant further work, considering that students had not previously owned a hand-held computer, and were assigned to the study according to their choice of modules rather than as volunteers. As ownership of PDAs, or mobile phones with PIM facilities, increases, demand for PDA-based study and learning tools may also grow. However, it must be remembered that our users were highly computer literate and, moreover, had a strong interest in computer technology and its uses. As well as extending the study with the current user group, it must also be applied in user groups studying different kinds of subjects, before any claims can be made about the generalisability of our findings. As mobile technology becomes a more intrinsic part of everyday life, it is important that these patterns and demands are known and understood.

Acknowledgements

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