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THE IMPACT OF MOBILE AND WIRELESS TECHNOLOGY ON KNOWLEDGE WORKERS: AN EXPLORATORY STUDY

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Abstract

Organisations continue to be disappointed at the difference that ICT has made to knowledge worker productivity. This paper reports an exploratory study of the extent to which emerging mobile and wireless ICT can support the mobile nature of the knowledge worker's job, including the impact that these technologies can have on working practices, collaboration processes, knowledge worker performance, and productivity. We investigated these objectives by the example of geographically distributed IT consultants who had voluntarily adopted a mobile working solution which combined wireless General Packet Radio Service (GPRS) phones, Tablet Personal Computers (PCs), Wireless Local Area Networks (WLANs) in the organisation's office buildings, and wireless broadband in the consultants' homes. Personal productivity gains resulted from consultants' ability to make use of previously unproductive time, access corporate information as needed, and communicate via multiple channels regardless of location. The new functionality, particularly of the Table PC, afforded the evolution of new working practices by supporting richer social connectivity, more engaging face-to-face interaction, with the technology becoming more a social medium rather than barrier. Although based on an early adopter sample of IT professionals experienced with adopting new technology, we conclude from the study that emerging mobile and wireless ICT may have a greater impact on productivity due to its ability to support the mobile and collaborative nature of today's knowledge workers' job.

Keywords: Knowledge worker, mobile working, mobile technology, wireless technology.

1 INTRODUCTION

The prosperity of Western economies depends increasingly on the productivity of knowledge workers who are about to become the largest group of the organisational workforce (Drucker 1999). Organisations have typically looked to Information and Communication Technology (ICT) to improve 'white collar' productivity and performance (Edelman 1981). However, empirical research confirms organisations' continued disappointment at the difference that ICT has made (Strassmann 1990, Nathan et al. 2003).

Knowledge workers typically work in service or technological roles, spending a significant part of their time communicating with peers and clients, producing and reviewing documents, identifying information, locating expertise, and performing parts of larger, collective tasks (Drucker 1999). Organisations have steadily evolved a physically distributed workforce, project-based structures, and less enduring team arrangements. These conditions of work mean that knowledge workers tend to spend a large share of their time away from the desk, travelling, and attending meetings in a range of locations.

A lot of knowledge workers' time cannot be effectively used, unless they are equipped with the ICT resources that allow them to access corporate systems and applications, and to communicate with peers and other stakeholders while on the move. Hopes have thus been raised anew by the latest developments in pervasive or ubiquitous computing, triggered by major advances in mobile and wireless communication technologies, such as Third Generation (3G) mobile phones, wireless network infrastructures, and wirelessly enabled portable computers and devices (Kleinrock 2001). Ubiquitous computing technology has been suggested to provide more adequate support for the working style of today's 'business nomads' like knowledge workers with extensive mobility requirements (Lyytinen & Yoo 2002).

Mobile working solutions typically require a combination of IT networks and devices, such as WLANs, internet-enabled mobile phones, and portable computers. The coupling of wireless connectivity via the Internet with an increasing sophistication of portable devices is addressing the requirements of mobile working styles, yet, at the same time, it is also changing the ways in which people communicate, collaborate, perform work, and access information (Sawyer et al. 2003). Knowledge workers can use these technologies to log on to their personal e-mail system, manage their calendar and contacts, as well as the electronic diaries of their peers; receive and send e-mails and instant messages; and access the Internet, corporate intranet and operational information systems while on the move.

It was the aim of this research to explore the extent to which emerging mobile and wireless ICT can support the mobile nature of the knowledge worker's job, including the impact that these technologies can have on working practices, knowledge worker performance, and productivity. This study investigated these objectives by the example of a geographically distributed IT consulting team which had voluntarily adopted a new mobile working solution that featured functionality with which the users had no previous experience. It combined wireless GPRS phones, Tablet PCs, WLANs in the organisation's office buildings, and wireless broadband in the consultants' homes.

The study found that consultants improved their performance and productivity through the technology-enabled ability to make use of previously unproductive time, access corporate information as needed, and communicate via multiple channels regardless of location. The new functionality, particularly of the Tablet PC, afforded the evolution of new working practices by supporting richer social connectivity, more engaging face-to-face interaction, with the technology becoming more a social medium rather than barrier. Although based on an early adopter sample of IT professionals experienced with adopting new technology, we conclude from the study that emerging mobile and wireless ICT may have a greater impact on productivity due to its ability to support the mobile and collaborative nature of today's knowledge workers' job.

2 THEORETICAL FRAMEWORK

IS researchers have begun to outline the “nomadic information environments” that knowledge workers with considerable mobility requirements will soon have at their disposal (Kleinrock 2001). In the emerging world of 3G and WLAN proliferation, digitisation, miniaturisation, and service integration are expected to offer unprecedented possibilities for communicating, accessing, and sharing information and resources while on the move (Lyytinen & Yoo 2002).

Given the relative infancy of mobile and wireless ICT, it is not surprising that very little empirical research is currently available on their organisational use and impact. Most research to date has focused on the technical aspects of ICT like the studies reported in the Special Issue of the IBM Systems Journal from 1999 or in the Communications of the ACM. There is quite a profusion of more commercially interested publications which address the capabilities and opportunities of mobile and wireless ICT, yet do not go into questions of adoption and assimilation into existing working practices (e.g. Hayes & Kuchinskas 2003). IS researchers commented that “very little research has been conducted on the social issues surrounding use of mobile or nomadic environments” (Cousins & Robey 2003, p. 1).

Recently, Lyytinen and Yoo (2002) have formulated a comprehensive research agenda outlining emergent research issues in nomadic computing environments for the individual, group, organisation, and the inter-organisational levels. In terms of individuals and groups, they argue that the impact of mobile and wireless technologies should be assessed in terms of performance, team processes, and the consequences of removing temporal, geographic, and technological restrictions (Lyytinen & Yoo 2002).

A widely tested and proven approach to identifying the performance impact and usefulness of new technology to adopters at all levels is provided by the various technology acceptance theories (Venkatesh et al. 2003). A particularly relevant framework for analysing the reasons why, or why not, individual users find a particular IT useful, how they assimilate new IT into existing working practices, and what performance difference use can produce, is provided by Davis’ (1989, 1993) Technology Acceptance Model (TAM). It builds on the premise that employees must use the technology and assimilate it into existing working practices for it to deliver to the performance improvements generally expected from IT investments (Lucas & Spittler 1999).

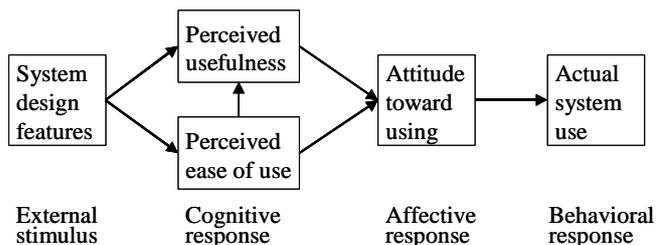


Figure 1. Technology Acceptance Model (Davis 1993, p. 476).

According to the TAM, the core determinants of a user’s attitude towards and resulting use of a given IT system are its perceived usefulness and perceived ease of use. Perceived usefulness represents “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis 1989, p. 320). Perceived ease of use concerns “the degree to which a person believes that using a particular system would be free of effort” (Davis 1989, p. 320). By explaining user acceptance through the perceived usefulness and ease of use of the IT system, TAM has been found to be most applicable to contexts where technology adoption is truly voluntary, rather than mandatory, as in many organisational deployments (Adams et al. 1992). In voluntary deployment, factors other than usefulness and ease of use intervene less in users’ acceptance decisions (Moore & Benbasat 1991).

Ease of use acts as an antecedent of usefulness, rather than a direct determinant of usage. In other words, users may find a given IT system to be useful to them, even though they experience the technology as difficult to use. The extent to which a user will find a given IT system easy to use and useful to perform the job, however, is influenced by the systems' design features (Davis 1993), although user training has been found equally important to obtaining the full benefits, particularly of modern and complex IT (Lucas & Spitler 1999).

Based on this literature, we designed an exploratory empirical study to address the following research questions:

- How did the users perceive the technology's ease of use?
- How usefulness was it to performing their job?
- How did the actual usage of the technology impact working practices, collaboration processes, and individual productivity?

The objective of the study was not to test the TAM in a positivistic sense, but to use it as a framework to inform the design of a semi-structured data collection instrument.

3 RESEARCH DESIGN

Given the immature state of empirical research on mobile working technologies, the study adopted a qualitative research strategy, using case study methodology (Eisenhardt 1989). A semi-structured data collection instrument was developed to conduct personal individual and group interviews. The design of the interview schedule was based on previous TAM research questionnaires used by Davis (1989), and Agarwal and Prasad (1999). To reflect the specific focus and context of our study, we extended these by including users' prior experience with information technology and the technology's perceived performance impact on team processes (effectiveness of the consulting process, collaboration with peers, and accessibility of team resources). The interview schedule is represented in Table 1.

Concept	Interview question	Reference
User context	<ul style="list-style-type: none"> • What is your role? • How long have you been working for this organisation? • How long have you been in your current job? • Expressed as a % ratio, how much does your role require working on your own versus collaborating with others? • Expressed as a % ratio, how much do you collaborate with others face-to-face versus electronically? 	Added by authors
Prior experience	Which of the following technologies have you used in the past? <ul style="list-style-type: none"> • Desktop PC; • Laptop; • PDA; • Mobile phone. 	Added by authors
New technology	Which of the new technologies do you use? <ul style="list-style-type: none"> • Tablet PC; • GPRS phone; • Corporate WLAN; • Domestic WLAN; • Public hotspots. 	Added by authors
Perceived ease of use	<ul style="list-style-type: none"> • Is it easy to remember how to perform tasks using [the target technology]? • Is it easy to get [the target technology] to do what you want it to do? • Is [the target technology] a flexible tool to work with? • Is it easy to learn how to use [the target technology]? 	Based on Davis, 1989, p. 340.

Concept	Interview question	Reference
	<ul style="list-style-type: none"> Overall, is [the target technology] easy to use? 	
	<ul style="list-style-type: none"> Is it easy to switch between [the target technology's] input functions? 	Added by authors
Perceived usefulness	Does using [the target technology] <ul style="list-style-type: none"> enable you to accomplish tasks more quickly? improve your job performance? give you greater control over your work? improve your productivity? enhance your effectiveness on the job? make it easier to do your job? prove, overall, to be useful in my job? 	Based on Agarwal and Prasad, 1999, p. 390.
	Does using [the target technology] <ul style="list-style-type: none"> improve the consulting process? enable you to collaborate better with others on your team? give you better access to team resources? 	Added by authors.
Attitude	<ul style="list-style-type: none"> Do you like using [the target technology]? Do you dislike using [the target technology]? 	Based on Agarwal and Prasad, 1999, p. 390.
Usage intention	<ul style="list-style-type: none"> Do you intend to completely switch over to [the target technology]? Do you intend to increase your use of [the target technology] in future? 	Based on Agarwal and Prasad, 1999, p. 391.
	<ul style="list-style-type: none"> Have you already completely switched over to [the target technology]? 	Added by authors.

Table 1. Data collection instrument.

Data were collected in face-to-face interviews with users of the mobile working solution. Next to the questions listed in the interview schedule, a range of prompts were asked to elicit the rationales underpinning users' views and to obtain illustrations of particular responses. Additional empirical material was retrieved in the form of documentary evidence on the deployment of the mobile working package. Furthermore, to support our ability as researchers to relate to users' reported experiences with the new technologies, we were provided by the case study organisation with Tablet PCs and GPRS phones, prior to the actual execution of the study.

All interviews were recorded and verbatim transcripts produced to ensure greater authenticity in the analysis of the collected data. We used two types of analytical validation. The transcripts were independently coded by the three researchers, and inter-subjectively validated by agreeing shared interpretations of the evidence where required. Researcher interpretations of the data were then administered to the study participants for review.

4 RESEARCH SITE AND DATA SOURCE

The empirical study was carried out at a major international vendor of commercial IT solutions that employs a workforce of around 50,000 globally. The organisation has its own research and development and manufacturing operations, and markets its products world-wide, mainly to large organisations. The case study was undertaken with thirteen IT consulting team members at one of the organisation's sites in the United Kingdom. The role of the consulting teams is to design customised IT solutions, which requires them to engage with the client to understand their business needs as well as to collaborate with engineers and systems developers to implement the solution.

A consulting team at the case study organisation typically comprises twelve members. The teams had previously used desktop PCs, laptops, conventional mobile phones, Personal Digital Assistants (PDAs) and paper notebooks to support their work and communications processes. In Summer 2003, a

pilot project introduced to 250 members of staff at the site, including the consulting team under study, for voluntary adoption, a mobile technology package combining Tablet PCs, GPRS phones, WLANs in the office buildings, and wireless broadband internet in employees' homes.

Specifically designed as a mobile computer, the Tablet PC combines laptop, planners, calendars, notebooks and handheld devices like PDAs into a single device, thereby replacing the range of electronic and paper-based resources that knowledge workers typically need to carry. The Tablet PC, by capturing and storing the full history of personal files, notes and records in digital form and providing full mobile access to the corporate systems, creates a new capability for knowledge workers to immediately have to hand all the resources they would normally have at their office desk regardless of location (Garfinkel 2004).

WLANs – corporate, public and domestic – provide mobile access to the Internet and corporate network resources. Corporate WLANs allow employees to use their laptop anywhere in the building with the same connectivity that they would have through a networked desk-top computer. Public WLANs offer broadband internet access on a pay-per-use basis at specific locations such as hotels, coffee shops, motorway service stations, railway stations, and airport lounges (Tachikawa 2003).

Whilst network reach of WLANs is typically restricted to a given building, mobile phone networks provide unrestricted wireless Internet access from any location and even whilst on the move. Many mobile networks have been enhanced to the so-called 2.5G (GPRS) which affords always-on Internet connection with sufficient bandwidth for email and web browsing. The emerging 3G network will dramatically increase bandwidth to provide real-time multimedia connectivity.

In total, thirteen members of two consulting teams who had taken up this new mobile technology solution participated in the study through personal interviews, which generally lasted 90 minutes. Interviewees included: two consulting team leaders (IID¹-06; ID-09); four consultants who were experts in business applications, like internet business solutions or customer relationship management (IID-03, IID-04; ID-10; ID-11); three technical consultants with special experts in product types such as telecommunications or web security (IID-07; IID-08; ID-12); two regional consulting managers responsible for managing a set of key customers (IID-02; ID-13); and two members of a pre-consulting support team (IID-01, IID-05). All data were collected throughout May 2004, eight months into the deployment of the new mobile working package.

Seven of the thirteen interviewees had worked for the organisation for more than four years. Three had worked there between one and three years, and the remaining three had worked there for less than one year. In terms of their current job role, five interviewees had been in their current role for more than two years, the other eight had been in their roles for less than one year. In terms of gender, only two of the interviewees were female, reflecting the wider workforce structure of the organisation.

Interviewees estimated that they spent between 50% and 90% of their work time collaborating with others, and using the remaining time to work by themselves. When collaborating, eight interviewees estimated that over 60% of their collaboration was electronic (e.g. using telephone, email, e-collaboration tools), and the remaining five reported a figure of more than 80%.

5 FINDINGS

5.1 Perceived ease of use of the mobile technology package

Interviewees consistently reported highly positive perceptions of the technology's ease of use (for a summary of results, see Table 2). An interviewee illustrated the ease of use experienced with the

¹ IID: Interviewee Identification.

mobile working package: “Although we’ve had wireless connectivity with the laptop, it required an external PC card and you couldn’t afford to leave that PC card in the laptop when you put it away because any mechanical force would snap it. So, you had to take it out every time, which meant disabling the PC card, pulling it out and it was a hassle to actually connect. With the Tablet PC it is already integrated, so, as soon as you walk into a wireless network area, you are working.” (IID-09)

Ease of using the mobile working package	Number of positive responses (n=13)
It is easy to remember how to perform tasks using the technology.	12
It is easy to get the technology to do what I want it to do.	10
The technology is a flexible tool to work with.	13
It is easy to learn how to use the technology.	10
It is easy to switch between the Tablet PC’s input options (e.g. digital pen, keyboard, speech).	13
Overall, the technology is easy to use.	12

Table 2. Results on perceived ease of using the mobile working package.

5.2 Technology impact on consultants’ working practices and performance

The data also revealed wide agreement among interviewees on the productivity and performance gains they experienced as a result of using the new technology. These findings are summarised at Table 3.

Usefulness dimensions	Examples of technology impact on job performance
Accomplish tasks more quickly	<ul style="list-style-type: none"> • Execution of tasks as and when they emerge
Improved job performance	<ul style="list-style-type: none"> • Saving time searching for and retrieving information • Speedier communications • Improved decision making through availability of right information
Greater control over my work	<ul style="list-style-type: none"> • Awareness of changes in daily work schedule • Improved personal time management
Improves productivity	<ul style="list-style-type: none"> • Use of otherwise dead time • Less duplication of re-work and effort
Enhanced job effectiveness	<ul style="list-style-type: none"> • Better collaboration • Better presentation quality
Makes job easier	<ul style="list-style-type: none"> • Enhanced ability to work away from desk
Improves consulting process	<ul style="list-style-type: none"> • Increased success in completing consulting assignments • Enhanced interactivity • Increased face-to-face customer contact
Collaborate better with others	<ul style="list-style-type: none"> • Faster completion of interdependent tasks • Making personal knowledge quicker available as team knowledge
Improved access to team resources	<ul style="list-style-type: none"> • Sharing of structured and unstructured information

Table 3. Technology impact on consultants’ individual and collective performance.

Faster task accomplishment. Using the technology enabled the consultants to accomplish tasks more quickly. The greater independence of physical location that the wireless connectivity of the Tablet PC provided allowed users to complete tasks on demand, as and when they emerged. A consultant explained: “Rather than having to return to my desk and connect to the network, I can perform tasks there and then, and I don’t have to interrupt the flow of a meeting in order to do something” (IID-11).

Improved job performance. More effective management of personal information, speedier communication processes, improved decision making, and greater effectiveness when working in meetings were examples given by interviewees to illustrate the ways in which the mobile working

package enhanced their job performance. The electronic notes taking and storing functionality of the Tablet PC allowed a more effective recording and sharing of personal notes regardless of location. It also saved consultants time searching for information, as illustrated in this example: “You can’t retrieve information from paper daybooks based on keywords and subjects – it is written in time, so you have to go through it chronologically. That’s an inefficient way of searching. I have the information quickly to hand now wherever I happen to be” (IID-09). Wireless accessibility of the personal email system was reported to speed up communication processes quite significantly: “Now, I am standing in a corridor, waiting for a meeting and I have got ten minutes, I just sit down and pop off a few emails, which is a large part of my job” (IID-03). The portability of the full history of personal documents, notes and communications on the Tablet PC combined with almost ubiquitous access to required information, whether stored on the Tablet PC or the corporate network, was felt to improve decision making: “What often happens in a meeting, you start off with an agenda but you drift off and you can, with the Tablet, access the information and say, OK, if we are going to talk about this, here is some material that might be of interest. And you feel more confident that you make the right decisions when you’ve got these things at your disposal” (IID-03). With all relevant resources at hand, the consultants felt better equipped and, therefore, more self-confident when visiting clients and working with others in meetings: “The Tablet improves my abilities to work in meetings – I don’t need to take paper files with me, I have electronic access to everything when and where I need it.” (IID-04)

Greater control over work. The technology provided the consultants with greater control over their work. Permanent connectivity via WLAN or GPRS aided personal time management and consultants’ ability to schedule and re-organise work: “It gives me more awareness. When I am using the Tablet PC in combination with the GPRS phone, then I have an awareness of all the meetings I am due to attend and, if things get difficult, I can reorganise effectively, rather than having to return to my desk and having to log in and find out what’s going on. I have more control over my life” (IID-07).

Improved productivity. Technology-enabled productivity increases were largely associated with ubiquitous connectivity. For instance, it allowed consultants to make use of time in situations where they previously could not. A team leader illustrated the point: “Rather than having five minutes dead time whilst I am waiting for someone to come to a meeting, I can sit there interactive with my Tablet and get a task done which I couldn’t get done previously” (IID-09). Productivity increases were also obtained through reduced re-work that interviewees associated with the efficiency with which they could record notes on the Tablet PC and share them with the team. “In meetings, I take notes now with the digital pen on the Tablet, I then just copy and paste that into an email, rather than taking notes on paper, going back to the office and typing them up” (IID-06). Given the nature of the consultants’ job, productivity gains through improved notes taking and sharing were significant, as they typically relied extensively on taking notes and sketching out solutions when developing client proposals. A consultant explained: “Traditionally, when I used flip charts for drawing diagrams and mind-maps, I ended up with a pile of flip charts and had to copy it down after the meeting from the whiteboard to the PC, laptop or on paper” (IID-08).

Enhanced job effectiveness. The technology was experienced to enhance consultants’ effectiveness on the job, by improving the quality of collaboration not only at a distance but also face-to-face: “You can draw things out as you think in front of the customer. This is especially beneficial in an engineering environment because most people are very visual. When you want to correct something, you just rub it out, whilst, with a paper pad, you take another sheet of paper and start again. Now, you can progressively build something, you don’t need to re-design it each time on a new page” (IID-08).

Makes job easier. All but one interviewee stated that using the technology made it easier for them to do their job. The benefits were associated with the mobility of personal and corporate information resources, which greatly enhanced opportunities for performing work out of a large range of locations: “I travel a lot in my job. Typically, a visit to Liverpool is a day out of my diary. So, I am waiting at the airport and if I’ve got wireless access, I can do my email, that saves a lot of time” (IID-13).

5.3 Technology impact on collaboration

We also investigated the perceived impact of the technology on team collaboration by asking interviewees to indicate whether using the technology had (a) improved the consulting process, (b) enabled them to collaborate better with others on their team, and (c) given them better access to team resources (see Table 3). Over half of the interviewees gave a positive evaluation of the technology's impact on collaboration, particularly through greater responsiveness, improved customer interaction, and reduced duplication of work. All of these improvements were associated with the mobile functionality of the Tablet PC and GPRS phone.

Improved consulting process. Interviewees explained how the use of the technology improved the consulting process. The 'always-on' connection via the GPRS phone made the consultants much more responsive to communications and queries, and thus expedited the consulting process: "You can be out at a customer site, expecting something very important to come in that you need act on immediately, such as closing a deal or clarifying a bid. If you use the GPRS phone, you can act upon it immediately. Whilst, historically, this could delay the process for half a day until you were back in the office" (IID-02). The slate form of the Tablet PC enabled new ways of engaging with customers when developing solutions. The interactive working style that the hand-drawing and hand-writing function of the Tablet PC offered aided the consulting process by involving all participants in the process, increasing the reflection of their views in the solution and, thus, enhancing ownership of the results: "Drawing jointly the process with the digital pen, instead of using PowerPoint slides, allows you to be more natural in your behaviour within a customer environment and that improves in the consulting process" (IID-07). Others stressed the time gains from using the technology and the resulting opportunity to dedicate more time to value-adding work: "Through the time it frees up, it enables me to allocate more time to working on consulting, as opposed to the background and admin work that needs to be done. It frees up more time to be face-to-face with the customer – more face-to-face time and less follow-up time from meetings with customers" (IID-13).

Improved collaboration. Interviewees agreed that the technology improved collaboration on the consulting team, resulting in faster completion of interdependent tasks: "Say, you've got four people who you need to go through to get a job done, you can get commitment within an afternoon. People go to various meetings at different times. When they come out it will be there. Then they can deal with it instantly" (IID-01). Others stressed how collaboration improved through the ease of turning personal electronic notes and documents into publicly available team resources: "I often put my Journal files into Siebel or attach them to an email and send them round after a meeting – you don't do that with paper. You very rarely share original notes on paper with your colleagues. I would type them up afterwards and do formal notes and then share them out. It's so handy to say, here are my notes from that meeting" (IID-04).

Improved access to team resources. There was also agreement that the technology enhanced the ease of building and accessing team resources, due to the ease with which knowledge on team processes could be captured in digital form and made available through the wireless connectivity: "From a collaboration point of view, sharing documents is quicker and you've got quicker access from wherever you are" (IID-02).

5.4 Attitude and usage intentions

Interviewees were enthusiastic about using the new technology and had already fully switched over, with the exception of one user who was aware that there was useful functionality available but he did not know how to use it: "I haven't been able to take advantage of the handwriting search functionality and I don't know how to get it to convert my handwriting into typeface. I understand that's there but I don't know how to do it" (IID-10). The main limitation to usage was not the functionality or lack of user friendliness of the technology but the lack of formal training in an organisation that assumes a high level of IT skills and relies on self and peer-to-peer learning when introducing new technology.

6 DISCUSSION

This research aimed to investigate the extent to which mobile and wireless ICT can support the mobile nature of the knowledge worker's job, using members of IT consulting teams as an empirical example.

6.1 Workplace independence

The design features of the mobile technology package studied in this research created new notions of usefulness both in social and individual settings. For instance, the form factor of the Tablet PC, consisting of its portability, light weight and electronic handwriting facility made it the first personal computer that users found acceptable to use within a social setting, such as in meetings with peers or customers. In slate mode, users took advantage of the electronic handwriting and drawing functionality of the Tablet PC to capture and store notes digitally. The Tablet PC presented users with a tool for holding the full history of personal documents, notes and communications. Wireless connectivity via corporate, public and domestic LANs or GPRS enabled users to access centrally located resources, regardless of location. Wireless connectivity created opportunities for carrying out tasks in contexts where this was previously impossible, such as accessing corporate information systems, sending and receiving emails on the train, using previously wasted time (e.g. waiting for a meeting to commence) and scheduling appointments with colleagues by accessing their electronic calendars while away from the office. Our findings, thus, suggests a link between the notion of workplace independence afforded by the new technology and the evolution of new working practices.

6.2 Collaboration processes

While the literature on distributed working has already stressed the fundamental requirement of remote systems access for employees working at a distance (Belanger et al. 2001), this research established evidence that social connectivity is an additional fundamental benefit for mobile workers. Both systems and social connectivity, our research would suggest, makes distributed and mobile working a far more effective working model for those who depend for their performance not only on access to corporate resources but also to peers and business partners. Traditionally, conditions like the time wasted through travelling, the burden of carrying paper resources, and the difficulties of remaining in contact with colleagues and customers have made face-to-face working inconvenient for mobile knowledge workers. As the ability to work regardless of location advances, using increasingly mature technology, these constraints will become less likely to constitute reasons for people *not* to work face-to-face. Mobile technology allows users to make effective use of their time, whether remote from the office or on the move.

In the organisation studied, GPRS extended peer contactability beyond conventional voice communication and SMS by providing always-on wireless access to email and shared diaries. This resulted in enhanced responsiveness to changes in the daily working schedule and to communications from colleagues and customers. Ubiquitous communications through a range of wireless channels like personal voice communications, conference calls, voice mail, email, access to users' own and peer calendars and contacts, make distributed workers more contactable, thereby, improving social connectivity across the organisation. It is important to recognise, however, that the users in this study did not encounter problems of systems and hardware interoperability (Lyytinen & Yoo 2002) because the technology package had only been provided to a small group of trial users (250 out of 50,000 employees) using identical hardware and software.

6.3 Individual working styles

Previous research has already reported that flexibility is an important determinant of systems uptake by users. By offering considerable discretion in exercising different functions and features, flexible

technology can be used in different ways, depending on the task's requirements and user's preferred working styles (Igarria et al. 1997, Lucas & Spitler 1999). The usability of the Tablet PC, for example, as a slate as well as conventional laptop, the choice of input and control options, including keyboard, mouse, digital pen and voice, provided users with great choice in accommodating their preferred working style. The Tablet PC, for example, offered users the option between text input using a digital pen or typing on a real or virtual keyboard; and drawing with either the digital pen or using a mouse. In managing their email and calendars, users also had the choice between using their smartphones, which users tended to do for sending short messages whilst travelling, or the Tablet PC, which was more suited to typing longer messages with attachments.

6.4 Reasons for adoption

All but one of the thirteen interviewees had fully adopted the mobile technology package. Users' reasons for adopting the new technology were clearly associated with the new design features of the technology, the new opportunities of usage they provided, as well as the ease of learning to use and using the technology. The one interviewee who had not fully switched over to the new technology yet explained that, in the absence of user training, he had not taken the time and effort to learn how to use it, and to explore what the benefits of the new usage options were. The limited uptake of the new technology by this user had, thus, less to do with the design of the technology than with the absence of training. This finding supports the claim by previous IS research that, to obtain the full benefits particularly of modern and complex technology, organisations should provide "training that demonstrates how the user might do his or her job differently, and how the technology enables different strategies and different approaches to one's job" (Lucas & Spitler 1999, p. 306). The only other criticism that was voiced by users concerned the hardware design of the particular model of Tablet PC implemented in the case study organisation. One user expressed preference for a lighter model, whereas most users considered its battery life as a major inhibitor of ease of use because users needed to carry a replacement battery or, alternatively, recharge the battery during the working day. Users unanimously agreed that full mobility was still restricted in public spaces due to the currently limited availability of hotspots and GPRS coverage in the United Kingdom.

7 CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

For decades, there has been significant concern about the failure of IT investments to increase knowledge worker productivity (Strassmann 1990, Drucker 1999). This exploratory study found that a package of mobile technologies can have a significant impact on the personal and collective productivity of a geographically dispersed, mobile team. From our study, we conclude that previous failure to improve productivity may be due to the unsuitability of IT to the mobile and collaborative nature of today's knowledge workers' job. Personal productivity gains can arise from mobile and wireless technologies that enable knowledge workers to make use of previously unproductive time, access corporate information as soon as it is needed, and communicate in real-time with colleagues and customers via multiple electronic channels regardless of location. In terms of working practices, the new functionality of the mobile working package afforded the evolution of richer social connectivity, more engaging face-to-face interaction, with the technology becoming more a social medium rather than barrier, and the flexibility to accommodate a diverse range of personal working styles.

Although the research findings indicate very positive impacts of the mobile working package, it is important to recognise that the case study evidence was elicited from an early adopter sample of IT professionals experienced with relying on electronic communication and working in a culture where assimilating IT into working practices is encouraged. This clearly represents a bias. Acceptance of a mobile working package without the provision of formal training has been found to be less likely with users who are less experienced in adopting advanced technology (Bagozzi et al. 1992). In this respect,

the implementation approach employed in the case study organisation cannot be readily extended to other user populations.

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