

THE APPROPRIATION OF PDAs AS
LEARNING AND WORKPLACE TOOLS:
AN ACTIVITY THEORY PERSPECTIVE

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Abstract

In recent years there has been a growing interest in exploring the use of mobile technologies to support learning and workplace activities. This thesis examines how one mobile technology – the palmtop computer or personal digital assistant (PDA) – has been used in different learning and workplace settings. The thesis draws on three in-depth case studies and one smaller observation study that examined the use of PDAs in the following contexts: (a) as tools for reading course materials by students on an Open University masters course, (b) as general workplace tools in an academic institution, (c) as mobile information management tools used by knowledge workers in an international organisation, and (d) as informal learning tools in a museum setting.

These studies primarily involved interviews with participants, which were supplemented by other data collection methods. The purpose of the studies was to uncover users' perceptions of the PDA, and explore how it had come to be integrated into – and subsequently changed – their learning and workplace activities.

The analysis of these studies focused on developing an understanding of the related concepts of tool appropriation and tool mediation. The thesis examines both how the PDAs were appropriated as learning and workplace tools, and how the PDA mediated – and consequently changed – the activities it was used to support. Concepts from activity theory were used in this analysis to help identify the sociocultural factors that influenced the process of tool appropriation, and to determine how the PDA mediated activities by introducing new possibilities and

constraints. The thesis describes tool appropriation and tool mediation as a two-way process, and emphasises that understanding these related concepts is an important aspect of research concerned with the development and use of new technologies.

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Chapter 1

Introduction

This thesis examines how palmtop computers – or Personal Digital Assistants (PDAs) – can be used effectively as learning and workplace tools. The purpose of this research is not to uncover usability issues (although these are certainly identified); nor is it to demonstrate how PDAs might improve learning or increase productivity in the workplace. Rather, through this research, the thesis aims to examine the concepts of *tool appropriation* and *tool mediation*, in order to better understand how people use personal and portable technologies, and to determine the effects such tools have on learning and workplace activities.

In this thesis, tool appropriation is defined as the integration of new tools into the user's activities. This is discussed further in Chapter 3 (Section 3.1). Tool mediation, meanwhile, refers to how tools are used to achieve certain objectives. That is, the tool mediates the relationship between the person (or user) and the goals he or she hopes to achieve (see Section 3.2). This notion of tool mediation assumes that tools or technologies are typically employed in objective-driven activity. However, technologies can also be used when the user has no clear purpose in mind other than “tinkering” with the technology, which could, in turn, enable the user to discover new objectives. This type of activity is known as *bricolage* (Levi-Strauss, 1966); however, it is not the concern of this thesis. Rather, this thesis is concerned

with understanding how PDAs can be used to support specific learning and workplace activities, and how they can consequently change those activities.

The notion of tool mediation is closely linked to the idea that new tools modify activities. That is, when a new technology comes to be incorporated as a mediating tool in a particular activity, it has the power to change that activity. For instance, mediating tools in an educational setting can shape learning activities: “This process of mediation provides a basis for arguments suggesting that technology can lead to educational reform ... any artefact, technological or otherwise, has the potential to change activity” (Bellamy, 1996, p. 124). It is this aspect of tool mediation that is the main concern of this thesis.

In the remainder of the thesis, then, I will be seeking to answer the following questions:

- 1. How are PDAs appropriated as learning and workplace tools?**

- 2. How do PDAs mediate (and consequently change) learning and workplace activities?**

I have chosen to focus on these questions because they highlight the varied and unique ways in which new technologies can become integrated into users’ learning and workplace activities. I aim to demonstrate in this thesis that individual users are different in the way they use personal technologies, and the sociocultural context in which new tools are used varies across activities. The factors that make a device

easy or difficult to use, then, and the issues that contribute to how well the new tool is accepted and integrated into the user's activities, will depend greatly on the context in which it is used. In order to understand how a new tool can be used effectively, and how that tool changes the activities it is used to support, it is important to look at the whole picture. This involves examining how new tools are actually used, and evaluating the use of new tools from the perspective of the users themselves, who are employing the technology in a variety of real-world settings.

In the remainder of this chapter I will provide further information about the research that was undertaken for this thesis, and summarise the research contributions that this thesis aims to make. This will be followed by an overview of the chapters to follow.

1.1. RESEARCH BACKGROUND

This thesis draws on, and contributes to, a set of related research fields whose aims include evaluating and understanding the way people use new technologies. These are human-computer interaction (HCI), educational technology, information systems (IS), computer-supported cooperative work (CSCW), and sociological research concerned with the social shaping of technology.

As the development and proliferation of new technologies rapidly evolves, so too must the research concerning how people use new technologies. Given the recent advances in the use of mobile technologies, a current research concern is to explore how these technologies can best be used as learning tools (e.g., Sharples, 2000), how they can support mobile working practices (e.g., Bellotti & Bly, 1996), and how their

development and use has been shaped by social and cultural factors (e.g., Harper, 2002). There has been a tendency for some authors to be overwhelmingly positive in their suggestions that mobile technologies will “transform” education and work (e.g., Soloway et al., 2001). However, in order to ensure that such technologies are used effectively in the future, it is important to build our understanding of how people currently use personal and portable technologies: how users feel about these technologies, what possibilities and constraints they present, and how they change the learning and workplace activities they are used to support. This thesis addresses these concerns. The development of the research is described below.

1.1.1. Choice of technology

This project began with a broad intention to evaluate the use of mobile technologies as learning and workplace tools, a timely concern given the discourse on new mobile technologies in the media, and the burgeoning academic interest in issues such as mobile learning, ubiquitous computing, and mobile work. Clearly, however, there were a lot of components of this project which needed definition before it could proceed.

Most importantly, I needed to determine what was meant by mobile technologies in the context of my research. At the time that the project began (October 2000), there was beginning to be a proliferation of mobile devices on the market (not just mobile phones). In addition, communications technologies were moving towards supporting the notion of “anytime, anywhere” information access, with Wireless Application Protocol phones (WAP) being touted as the next revolution in mobile computing, enabling access to the Internet from mobile telephones. Similarly, Bluetooth and wireless technologies were also being deployed, enabling mobile devices, such as

PDA's, to be wirelessly connected to networks and other computers. However, these developments were disappointingly slow and, in the case of WAP, did not live up to initial expectations (Naughton, 2001). Although researchers were beginning to explore the possibilities of using handheld computers with wireless communication capabilities, such studies typically involved the use of industry prototypes which were beset with technical difficulties, such as unreliable communication links and frustratingly slow download times (e.g., Lundby, 2002). Without links with industry it was not realistic for the research undertaken for this thesis to examine new technologies that were not yet widely available. This would have involved access to prototypes and to infrastructure which wasn't yet fully developed and deployed.

Therefore, I decided to focus on a portable technology that did not have communication capabilities, and was already widely in use and embedded in the early adopters market: the PDA. This had the advantage of being commercially available and therefore easy to access, while it was still in the process of being discovered as a new tool by various sectors of the market, such as non-management workers and the education sector. Thus, the project became an evaluation of the use of PDA's as learning and workplace tools.

Throughout this thesis, the terms *tools*, *technologies* and *artefacts* are used interchangeably to refer to the PDA and the other devices that people use to support their learning and workplace activities. However, some preference is given to the term tool to describe the PDA, as this signifies that it is being used for a particular purpose. That is, it is not the PDA itself that is being examined in this research. Rather, the research focuses on the *PDA-in-use*. However, the PDA is a

multipurpose device; therefore, it can be problematic to refer to the PDA as an individual tool, as this hides that it is in fact many tools incorporated into the one device. For instance, the PDA can serve as a diary or a calculator, a to-do list or an address book.

To overcome this problem, in this thesis I have used the term tool to refer to the PDA, but have specified throughout what it is being used for. When speaking of tool appropriation, for example, I am referring to how users have chosen to appropriate the device itself. An integral part of this is which applications the user has chosen to use. Thus, understanding the PDA's role as a tool means understanding the meanings users have ascribed to it, and what purposes it fulfils. This is one of the reasons why the context of use is important when evaluating a multipurpose and personal technology such as the PDA. The PDA can only really be understood as a tool with reference to how it is used. In other words, "*a tool is what it is used for*" (Bannon & Bodker, 1991, p. 238).

It can also be problematic to refer to numerous devices under the one label ("the PDA"). There are, in fact, many different types of PDAs on the market (see Chapter 2), with various functions and capabilities. The devices examined in this research could be divided into two main types: Palms and Pocket PCs. The latter run on a Microsoft operating system and share many of the features and capabilities of Microsoft desktop software. Palm devices, on the other hand, are more simplistic. Older versions of Palm PDAs, in particular, were designed to offer users basic functionality with an uncluttered interface. These devices have typically been used as electronic diaries and address books. Most of the participants in the research

presented in this thesis used Palm PDAs. For the sake of simplicity, then, this thesis uses the term “the PDA” to refer to all the devices that were examined in this research, although I acknowledge that different devices have different constraints, affordances, and interface features. Where these differences are relevant, then, they will be specified and I will make clear which particular device is the subject of the discussion. I will provide further information about “the PDA” in Chapter 2.

1.1.2. Introduction to studies

This thesis is based on three in-depth case studies, and a smaller observation study, which each examined the use of PDAs in a different learning or workplace context:

- 1) Case Study A looked at the use of PDAs as tools for reading course materials on an Open University course.
- 2) Case Study B examined the use of PDAs as workplace tools in an academic institution.
- 3) Case Study C evaluated the use of PDAs as mobile work tools in a large international organisation, known here as NatGasCorp (NGC).
- 4) The final study was a small-scale observation study that served as an illustration of the use of PDAs as informal learning tools in an art gallery (the Tate Modern in London).

For each study, data were primarily derived from interviews with participants; 62 interviews were conducted in total. These were supplemented by data from observations, questionnaires, and contributions to online discussions. The participants, methods used, foci, and time scale for each study, are summarised in Table 1-1. The methods used will be described in more detail in Chapter 4.

Table 1-1. Summary of the four studies

Case Study A (PDAs as reading tools on an Open University course)				
Context	Time	Methods	Participants	Focus
Open University masters course; Palm PDAs supplied to students; PDAs used to read course materials	July – October 2001	Pre-questionnaire	44 students responded	Student expectations about the PDA & past experience
		Interviews (2 months after students received PDAs)	10 students, randomly selected; 4 male, 6 female	How students had used the PDA; how the PDA had changed their reading activities.
		Post-questionnaire	35 students responded	How students had used the PDA; what their perceptions were of the PDA; how it had changed their reading activities.
		Contributions to online discussion	27 students contributed	An opportunity for students to discuss how they used the PDA.
	July 2002	Follow-up interviews	8 students who responded to an email; 2 male, 6 female.	How & why students had (or had not) continued to use the PDA (or their own palmtop computer).
Case Study B (PDAs as workplace tools in academic institution)				
Context	Time	Methods	Participants	Focus
Academic department: the Institute of Educational Technology, Open University; Palm/Handspring /Jornada PDAs supplied to 11 staff members; PDAs used as time and information management tools	June – Dec 2001	Introduction to PDA	11 staff members; 5 male, 6 female	Help with set-up procedure; observation of initial reactions
		Interviews	All participants	Participants' perceptions of the PDA, how it had been used.
		Email discussion	All participants	Discussion amongst participants about how they were using the PDAs.
	April 2002	Follow-up interviews	4 participants, selected to represent different levels of PDA use	Why some participants did or did not successfully integrate the PDA into their work activities.
	Nov – Dec 2003	Final interviews	9 participants who responded to follow-up email.	How use of the PDA had changed over two years since initial interviews.
Case Study C (The use of PDAs as workplace tools in NGC)				
Context	Time	Methods	Participants	Focus
Large international organisation; Palm PDAs supplied to management staff 3 years prior to study; used to support mobile work.	July – Sep 2002	Interviews	16 staff members; 12 male, 4 female	How staff used PDAs and other mobile technologies, exploration of general work practices at NGC.
		Observations of two staff seminars	Staff running & attending seminars	Information about technology provision at NGC; staff concerns about technology limitations.

Observation Study (PDAs as informal learning tools in the Tate Modern)				
Context	Time	Methods	Participants	Focus
Tate Modern art gallery; PDAs supplied by Toshiba; use of PDAs as multimedia tour guides currently on trial.	Dec 2003	Participant observation	Myself & one volunteer	Observation of the use of the PDA as a multimedia tour guide.
		Informal interviews	5 visitors to gallery; 3 male, 2 female.	Perceptions of the PDA and how it mediated the activity of learning about the artefacts on display.

1.2. CONTRIBUTIONS OF THE THESIS

As aforementioned, this thesis is an exploration of the use of PDAs as learning and workplace tools. The research includes an evaluation of the PDA which focuses on identifying the possibilities and constraints introduced by the PDA in each of the case study settings, and determining how these possibilities and constraints affect the users' activities (based on the task-artefact cycle by Carroll, Kellogg, & Rosson, 1991 - see Chapter 2). Evaluation is an important element of research concerned with the use of new technologies, particularly in the fields of HCI and educational technology (Jones et al., 1999). Evaluation can help technologists design more useful and usable computer systems, and ensure that those systems are employed in a way that meets the users' needs. The evaluative strand of this thesis focuses on users' perceptions of the usefulness and usability of the PDA. However, the evaluation findings do not represent the sole contribution of this thesis. The thesis also provides a rich account of the processes of tool appropriation and tool mediation. In addition, this thesis presents a novel way of using activity theory as an analytical framework for examining the process of tool appropriation, and presents a model – based on the data from Case Studies A and B – that describes how a new

tool comes to be integrated into (and consequently changes) existing activities. These contributions are summarised briefly below.

1.2.1. Tool appropriation and tool mediation: a two-way process

A central argument of this thesis is that the concepts of tool mediation and tool appropriation together describe the two-way process by which new tools are integrated into existing activities. That is, when users integrate (appropriate) new tools into their activities, the new tools change (mediate) those activities in various ways. The process of appropriation is influenced by the social system into which the new tool is introduced; meanwhile, the new tool has a modifying effect on that social system. This process has been described elsewhere as a “coevolution” of tasks and artefacts (Carroll et al., 1991), and the “reciprocal shaping” of technology and society (Brosveet & Sorensen, 2000). While this two-way process is widely acknowledged in the literature, I am not aware of any studies that have explicitly set out to examine the related concepts of tool appropriation and tool mediation, and to define this two-way process with reference to a specific instance of new technology use. Thus, this thesis offers a contribution to this field of knowledge.

The importance of understanding the way social systems shape technology use was highlighted by MacKenzie & Wajcman (1985), who criticised the technological determinism present in much of the social science research that aims to uncover the impact of new technologies on society. MacKenzie and Wajcman did not discount the view that technologies change society. Their criticism was levelled at the belief that technology is somehow distinct from society, that its influence over society comes from the “outside” rather than from within. However, as MacKenzie and Wajcman argued, technologies are an inherent part of the societies in which they are

produced and used, and cultural factors are important in determining if and how new technologies will be used:

The device itself does not force societies to adopt it. We know of plenty of instances where technologies later judged useful or essential were not taken up, or at least were strongly resisted . . . *The characteristics of a society play a major part in deciding which technologies are adopted. ...[Furthermore] the same technology can have very different “effects” in different situations.* (p. 6; italics in original)

One of the benefits of the case study approach taken in this thesis is that I have been able to identify the mediating effects of PDAs in a variety of different settings, acknowledging MacKenzie and Wacjman’s point that the same tool can have different effects in different settings. Furthermore, my aim in examining the process of tool appropriation in this thesis is to identify how sociocultural factors have an influence over how new tools are adopted and used. Activity theory has proved valuable as a way of identifying and framing these sociocultural factors. In particular, as described below, the concept of an activity system will be used in later chapters to identify the sociocultural influences over the process of tool appropriation.

1.2.2. The ASTAM framework

The *Activity System Tool Appropriation Model* (ASTAM), which is developed and used in this thesis as an analytical framework for examining tool appropriation, builds on Engestrom’s (1987) depiction of an activity system. According to Engestrom, activity systems include the subject(s) (or actors) undertaking the activity, the objective towards which the activity is directed, the mediating tools, and the community, rules, and division of labour which together describe the sociocultural context of the activity.

Drawing on Marx's dialectical materialism, activity systems are said to be in a constant state of transformation, driven by contradictions both within and between activity systems (Engestrom, 1993). Thus, in activity theory terms, an activity is not a discrete task or action as it is understood in common use today. Rather, it is a constantly evolving sociocultural system. For instance, an organisation or educational setting could be described as an activity system; such activities have formed the focus of much of Engestrom's work (e.g., Engestrom, 1993; Hasu & Engestrom, 2000).

Activity theory is clearly a relevant framework for understanding the concept of tool mediation: one of the central tenets of activity theory is the notion that all activities are mediated by the use of tools, both conceptual tools, such as language, and physical tools, such as technological artefacts (Leont'ev, 1978; Nardi, 1996a; Vygotsky, 1978). However, as Bodker (1996) acknowledged, artefacts not only mediate our interaction with the world; they can also be the objects towards which our activities are directed. Drawing on this notion, this thesis uses the activity system framework to analyse the process of tool appropriation as an activity itself, where the object of the activity is the tool being appropriated – in this case, the PDA. The mediating artefacts in this activity include both the tools used to support the appropriation activity – for instance, instruction manuals specifying how to use the new tool – and the existing artefacts with which the new tool must become integrated. The community in this activity system includes other people who are also involved, to some extent, in the activity – for instance, colleagues, friends, and technology providers. The rules and division of labour might include regulations

governing the use of the new tool – for instance, how it is expected to be used – and a separation of responsibilities for installing software and overcoming technical difficulties.

Describing tool appropriation as an activity system makes it possible to examine the multiple interconnected sociocultural factors that exert an influence over the process of tool appropriation. In this thesis, then, I have adopted this activity system model as an analytical framework for examining the process of tool appropriation. The ASTAM framework will be described further in Chapter 3 and put to use in Chapter 5 in an analysis of tool appropriation in Case Studies A and B.

1.2.3. An activity theory analysis of tool mediation: the TIP model

In this research, I have also used concepts from activity theory to analyse how the PDA changed the activities it was used to support. In particular, this analysis draws on the concepts of *contradictions* in the activity system and *breakdowns* in the actions and operations that make up the activity – which will be described further in Chapter 3. This analysis also focuses on the possibilities and constraints introduced by the PDA, drawing on the task-artefact cycle, which was described by Carroll et al (1991), in which new tools are said to introduce both possibilities and constraints that change the tasks they are used to support.

This analysis is used, in Chapter 6, to develop a model describing the *Tool Integration Process* (the TIP model). This model illustrates how the possibilities and constraints introduced by a new tool can change activities. For instance, the possibilities of a new tool may help to resolve contradictions in an activity system. Meanwhile, the constraints of a new tool mean that breakdowns in the activity may

occur, new tool-oriented actions may be required (in other words, the user will need to focus on the tool itself rather than on the goal of the activity), or the user may need to adapt the way she uses the tool in order to overcome the tool's limitations. This model will be described further in Chapter 6 with reference to data from Case Studies A and B.

1.3. OVERVIEW OF THESIS

The remainder of this thesis will describe the technical and theoretical background to this research, present the findings of each of the four studies, and review the contributions of the thesis.

Chapter 2 describes the development of the PDA and looks at some of the recent research that has examined the use of PDAs as learning and workplace tools.

Chapter 3 describes the theoretical background to this thesis, focusing on the central themes of tool appropriation and tool mediation. This chapter will also describe the main concepts from activity theory that have informed this research.

Chapter 4 describes the methodological issues that informed the design of this research program, and provides an overview of the methods used in each of the four studies (as summarised in Table 1-1).

Chapter 5 addresses the first research question of the thesis: how are PDAs appropriated as learning and workplace tools? This will be discussed with reference to Case Studies A and B, which are analysed together because they present similar

findings regarding the sociocultural factors that influenced the way the PDA was appropriated by different participants in each study. The ASTAM framework will be used in this chapter to analyse the activity of tool appropriation.

Chapter 6 addresses the second research question: how do PDAs mediate learning and workplace activities? Again, this is discussed with reference to data from Case Studies A and B. In this chapter I will look at how the PDA mediated the activities of reading course materials (Case Study A) and workplace time and information management (Case Study B). This chapter will present the *Tool Integration Process* (TIP) model, which describes how new tools change the activities they are used to support.

Chapter 7 presents the findings from Case Study C. This chapter also uses the ASTAM framework to analyse how the PDA was appropriated in this context. Therefore this chapter further contributes to the first research question of the thesis: how are PDAs appropriated as learning and workplace tools?

Chapter 8 presents the findings from the observation study. This chapter describes how the PDA was used by visitors to the Tate Modern gallery, serving as an illustration of one context in which PDAs have been used as informal learning tools.

Chapter 9 reviews the findings of the four studies and reflects on how the research contributes to an understanding of the related concepts of tool appropriation and tool mediation. This chapter also discusses what the findings tell us about the value of the PDA as a learning and workplace tool.

Chapter 10 concludes the thesis with an overview of its main contributions and a discussion of possible directions for future research.

Chapter 2

PDA's as Learning and Workplace Tools

This chapter sets the scene for the remainder of the thesis by describing the technology that links the four studies in this research: the Personal Digital Assistant (PDA). Following an overview of the development of the PDA – focusing in particular on the *PalmPilot* – this chapter will describe some of the uses for PDAs that have been explored in the literature on learning and workplace technologies. One of the aims of this discussion is to clarify the concepts of *mobile computing*, *mobile working* and *mobile learning* with regard to how these terms have been applied in academic discourse. The purpose of this chapter, then, is to provide a context for the research that has been undertaken for this thesis. The chapter concludes with a cautionary note against the “pro-innovation bias” present in much of the research on the use of new technologies. Given this, an approach is outlined that aims to assess both the possibilities and constraints of PDAs as learning and workplace tools.

2.1. THE PERSONAL DIGITAL ASSISTANT

The Merriam-Webster Online Dictionary (2004) gives the following definitions for each of the words that make up the acronym PDA:

Personal = “of, relating to, or affecting a person ... done in person without the intervention of another ... relating to the person or body”

Digital = “... of, relating to, or using calculation by numerical methods or by discrete units”

Assistant = “a person who assists: HELPER”

These definitions give some insight into the meaning embodied by the PDA. The PDA is personal. It belongs to the person who uses it, it contains personal information, and its portability means that it can often be physically located on the user’s person – in the palm of one’s hand, or stored in a shirt pocket or handbag. The digital nature of the PDA relates to its electronic format, which is not fully evoked by the definition above. It is the digital nature of the PDA that gives it status as a computing technology. Finally, the PDA is a faithful assistant, helping the user to manage her personal information and day-to-day life.

Currently, there are many PDAs available on the market, as well as numerous *smartphones* – mobile phones that incorporate PDA functionality. In fact, the recent explosion of smartphones onto the market has led some commentators to declare the PDA “dead,”¹ a suggestion that might have some credibility given a recent announcement by PalmOne – one of the leading PDA manufacturers – that the company will now concentrate solely on producing PDAs that are embedded with mobile phone technologies (Pen Computing, 2004).

¹ This is a comment two conference attendees made in response to papers I presented at two conferences in 2003.

However, there continues to be a growing interest in the use of PDAs and other mobile technologies as tools for supporting learning and workplace activities (e.g., Lundin & Magnusson, 2003; Roschelle, 2003; Sharples, 2003; Soloway et al., 2001). In particular, much attention has been given to the possibilities provided by handheld computers with wireless communication capabilities that can be used, for example, to connect to local area networks, to access the Internet and email, and to talk to other people (Roschelle & Pea, 2002). However, as discussed in Chapter 1, at the end of 2000 (when this research was begun) such wireless technologies, although available, were not in widespread use. Thus, the research reported in this thesis primarily focuses on the use of non-networked PDAs.

Current PDAs can be divided into two main types, based on their operating systems: *Palm* PDAs, and *Pocket PC* devices. The former were the first (along with the discontinued *Psion* in the UK) to achieve market success. The original PalmPilot, which was released in 1996, was successful in both North America and Europe, and is viewed as the “granddaddy” of PDAs (Geisler, 2003). Most of the devices used in the three case studies reported in this thesis were Palm PDAs. The following discussion, then, charts the development of the PDA with a particular focus on how the PalmPilot came into being.

2.1.1. Antecedents of the PalmPilot

According to Geisler (2003), there were four main antecedents that contributed to the development of Palm technologies: (1) paper-based artefacts such as paper diaries and address books, (2) personal computing, (3) a social movement towards increasing professionalisation and the corresponding emphasis upon personal time management as a means of controlling one’s working conditions, and (4) awareness

of the compatibility between technologies and the human body. The Palm was preceded, in the early 1990s, by various electronic diaries and address books and the *Apple Newton*, an early handheld computer. However, according to the designers of the Palm, the Apple Newton was expensive, large and awkward to use, while the electronic organisers, despite being small and cheap, were difficult to use (Bergman & Haitani, 2000).

The Palm team, led by Jeff Hawkins, was originally employed to produce software for other handheld products. Hawkins believed that there could be a “happy medium” between the Apple Newton and the electronic organisers, and so the team set out to design it. They went to great effort to avoid designing a “mini-computer,” a concept they found difficult to convey to other technologists in the field who were entrenched in the design of personal computers (Geisler, 2003). As Rob Haitani – one of the original Palm designers – described, early user testing revealed that their potential users (primarily business people) already owned personal computers. Their strategy, therefore, was to design a device that could be used as an adjunct to a desktop or laptop computer. Thus, easy synchronisation with the desktop computer was a key design requirement from the beginning. This led to the development of *HotSync*, the synchronisation technology which transfers data from the Palm to the computer (and vice versa) through a cable connection (Bergman & Haitani, 2000).

2.1.2. Screen size limitations

Another original criterion of the PalmPilot was that it would fit into the user’s shirt pocket.² Inevitably, this criterion led to severe constraints regarding screen size and

² The shirt pocket being more limited in size than, for example, a handbag.

text input mechanisms. The designers, therefore, adopted a minimalist design approach which they labelled the “Zen of Palm” (Barnett, 2000). As Haitani described it, they had to make “every pixel count” (Bergman & Haitani, 2000, p.5). The screen interface for each application went through many variations, and features that weren’t absolutely necessary were stripped back.

The designers therefore chose to focus on a small number of functions that were found to be important in their initial user testing: the calendar, address book, to-do list and memo pad. Each of these had a paper equivalent, and the belief was that having them all in one device, in digital format, would be superior to paper (Barnett, 2000). The aim was to create a product that was better than paper, not a product that would compete with the PC. The intention was to provide fast and reliable access to the core functions, while other less frequently-used tools were hidden behind the immediate interface, so the screen did not become cluttered with too many icons and menu options (Bergman & Haitani, 2000). The resulting PalmPilot had four external buttons that, when pressed, opened the corresponding application. Thus, one of the main advantages of the Palm over other technologies, such as the laptop computer, was that the Palm could be instantly switched on and did not require a lengthy boot-up procedure.

The external buttons on the PalmPilot provided access to the Date Book, Address Book, ToDo or Memo. These are the names that Palm has given these applications. In the remainder of this thesis, the terms *calendar* and *diary* are used interchangeably to refer to the Date Book (and similar applications on other systems), while the Address Book is also referred to as a *contacts database* and the Memo as a *notebook*

or *notes*. This is to ensure that generic terms are used, which can apply to different PDA and personal computing platforms.

2.1.3. Text input

The PalmPilot had a touch-screen interface with pen-based input. There were two main methods for text entry: tapping out letters on a small onscreen keyboard, or using the *Graffiti* handwriting system. As Jeff Hawkins described it, Graffiti grew out of earlier unsuccessful attempts to create accurate (and natural) handwriting recognition software. Unable to get computers to recognise human handwriting, Hawkins decided to invent a system that required users to learn the computer's method for handwriting (Barnett, 2000). Thus, Graffiti consists of a set of character strokes which in many cases closely resemble their associated alphabet characters.

Despite suggestions that Graffiti is easy to learn and use (Barnett, 2000), a recent study compared Graffiti unfavourably with a similar commercially available handwriting system called *Jot* (Sears & Arora, 2002). In the study, 16 student volunteers used Graffiti, and 15 used Jot to complete a number of experimenter-set tasks that were designed to emulate realistic PDA data entry tasks, such as recording contact information and entering a URL. The study found that using Graffiti was slow, with participants entering data at an average of 4.95 words per minute. It was also error-prone. The experimenters identified several “periods of difficulty” where participants spent more than five seconds attempting to write a single Graffiti character. However, this study did not examine the use of Graffiti in a real-world context. Participants were novices carrying out a set of experimenter-designed tasks; their performance could therefore have been quite different to that of real users who would use Graffiti over an extended period of time.

Nevertheless, the study did demonstrate some of the usability issues that plague Graffiti and other similar PDA text entry systems. Since the days of the PalmPilot and its predecessors, text entry limitations have continued to be a problem for handheld computers. Most current PDAs still use some form of pen-based handwriting like Graffiti. However, there are also many portable foldout keyboards that attach to the PDA and give the user access to a full-size QWERTY keyboard (see Figure 2-1). In addition, some handheld devices have built-in keyboards. For instance, earlier Psion handhelds had a “clam-shell” appearance, opening up to reveal an integrated keyboard (Healey, 2000), while the latest Palm device – a PDA with mobile phone functionality, called the “Tungsten W” – has a small built-in keyboard, designed to be operated by the user’s thumbs (PalmOne, 2004c). Nevertheless, the size constraints of portable devices such as PDAs mean that text entry limitations may never be fully overcome.



Figure 2-1. Palm PDA attached to foldout keyboard

2.1.4. The current picture

In recent years, there have been numerous additions to the PDA market. Perhaps the most well-known of these are the Microsoft Pocket PC devices, which are manufactured by Dell and Compaq (for example, the *iPAQ*). The Pocket PC devices were designed to emulate Microsoft PC applications as far as possible, so as to take advantage of the intended users' previous experience of the Windows interface and Microsoft software (Zuberec, 2000). Therefore, these devices extended the functionality of earlier PDAs, and included applications such as word processors, spreadsheets, email and Internet browsers. They also had colour screens and often incorporated video and audio facilities. Thus, they gained a reputation as “the best multimedia handhelds” (Doe, 2003).

However, their colour screens and memory-dependent applications meant that battery life was poorer on these devices than it had been on the Palm PDAs. Nevertheless, following the market success of the Pocket PC, many of the new Palm-

based devices also now come with colour screens and expansion slots so that users can add extra hardware to the device (Doe, 2003). In addition, there is a great variety of third-party software available for Palm PDA's.³ Most PDA's also have an infrared port, through which information can be “beamed” from one device to another, while many have wireless cards, so they can be connected to a wireless network. Some PDA's also contain Bluetooth technology, which enables wireless connection to other Bluetooth-enabled devices, such as mobile phones or laptops (Smith, 2003). Therefore, PDA's can be used to support a wide range of activities. Given this, in the following sections I will review some of the uses that have been made of PDA's in various learning and workplace settings. In addition, the following review aims to clarify the concepts of mobile computing, mobile working, and mobile learning.

2.2. THE PDA AS A WORKPLACE TOOL

The PDA is commonly referred to as a *mobile technology*, along with the more ubiquitous mobile telephone and other portable devices (Harper, 2002). The concept of mobility – as applied to mobile work, mobile learning, and mobile computing, for example – has been widely used in recent years in both popular and academic discourse, leading to suggestions that it is in danger of becoming a “buzzword” (Kakihara, 2003). As Churchill & Wakeford (2002, p.136) have argued, there are “discourses of mobility” in the popular media that convey idealised notions of mobility and illustrate how people believe mobile technologies *should* be used, particularly in relation to their use by mobile professionals. Therefore, before reviewing the use of PDA's as workplace tools, I will first examine the discourse

³ Third-party software refers to software made by developers other than the Palm organisation.

surrounding mobile computing and mobile work in order to understand how the PDA is perceived as a mobile and workplace technology.

2.2.1. Mobile computing & mobile work: “access anytime, anywhere”

The term *computing* no longer just refers to using a computer to calculate or transform data. In common use today, it has a much broader meaning, referring to any activity that involves using a computer, including, for example, word processing, storing information on a spreadsheet, browsing the Internet, or sending an email (Norman, 1999). According to Kleinrock (1996), an assumption many of us make about our computing environments is that we are always connected, whether that means being connected to the Internet, email, networked computers, or simply being connected to the information stored on one’s own personal computer. Given that Kleinrock made this declaration eight years ago, when the widespread use of the Internet was still in its infancy, the link between *computing* and *connectivity* must be even stronger today. Indeed, mobile computing is often referred to as “access anytime, anywhere” – a phrase that could be considered synonymous with the notion of remaining constantly connected to people and information (Perry, O'Hara, Sellen, Brown, & Harper, 2001).

According to Perry and colleagues, the concept of access anytime, anywhere requires some clarification, given the multitude of meanings that can be ascribed to each term. Their study of mobile workers found that *access* to information meant different things according to how that information was to be used. The varying circumstances encountered by mobile workers led to the need for diverse types of information access. For instance, when short periods of time were available, it was more

convenient to use mobile telephones to communicate with colleagues, while the use of email was reserved for longer stretches of otherwise “dead time.” Similarly, the type of information required in meetings (for example, paper documents) differed from the sort of information access that was appropriate when driving (voice communication), which again differed from the type of information that could be used when travelling by aeroplane (for example, documents stored on a laptop computer). Thus, the authors concluded that flexibility in technologies and resources was the key to providing access anytime, anywhere.

Other recent research into mobile working has provided a wealth of information about what mobility actually means in different workplace contexts. One of the main findings is that mobility means much more than geographical movement between countries, cities or offices. Rather, all work is mobile in the sense that it involves movement within physical spaces. Kleinrock (1996) used the term *nomadicity* to refer to the inherently mobile nature of human beings. He gave the example of moving from his desk to a conference table in his office which “constitutes a fundamentally nomadic move since the computing platforms and communications capability may be considerably different at the two locations (even though they are separated by no more than 5 feet)” (p. 351).

Describing this type of movement, Bellotti and Bly (1996) coined the phrase “local mobility,” referring to movement within easy walking distance – for example, between desks, offices, and co-located buildings. In their observations of design workers, Bellotti and Bly found that movement within the local vicinity was very important for supporting collaborative work. Workers could keep track of each

other's progress on joint projects – and maintain awareness of other ongoing projects – simply by wandering about the office and chatting to colleagues. This often occurred on a casual basis. Unanticipated contact with colleagues led to serendipitous knowledge-building. However, while local mobility enhanced collaboration between physically co-present workers, it was detrimental for collaboration between distributed colleagues. People who frequently moved about the office were rarely at their desks and therefore were difficult to contact or locate. Thus, distributed co-workers found it difficult to maintain awareness of each other's progress. For Bellotti and Bly, then, the challenge of providing technological support for mobile collaborative workers meant finding ways of supporting distributed collaboration whilst not compromising local mobility. They described some prototype technologies designed to meet these needs, but in the eight years since this research was published most of the available computing support for collaboration – for example, email – remains predominantly desk-bound, despite the increasing interest in the use of mobile technologies to support collaborative work (e.g., Lundin & Magnusson, 2003).

In another observation study of mobile workers (including business travellers and those whose mobility was more localised), Sherry and Salvador (2002) were struck by the “rather rudimentary paper management schemes” that mobile workers used. They suggested that there was the need for a product that fitted the gap between PDAs, which were “simply too difficult to use for any kind of data entry beyond contact information, passwords or calendar entries,” and laptops, which were encumbered by their heavy weight, lengthy times required to boot-up, and “the inappropriateness of using a large, rather noisy machine in the middle of a variety of

social situations” (p. 117). In an attempt to address this gap, technology companies such as Microsoft and their partners have designed pen tablet computers, which are smaller and more lightweight than laptops and are designed to be used like paper, with pen-based text input on a touch-screen interface. However, the expense of these devices has led some commentators to suggest they may have a short commercial lifetime (Hachman, 2004).

The use of paper also featured heavily in the review by Luff and Heath (1998) of three studies examining different types of mobile workers. They expanded the concept of mobile work to consider the mobility of *artefacts* at the user’s disposal. They termed this *micro-mobility*, defined as “the way in which [an] artefact can be mobilised and manipulated for various purposes around a relatively circumscribed, or ‘at hand’ domain” (p. 306). In these terms, paper artefacts have a high level of micro-mobility.

Luff and Heath described two workplace contexts in which computing devices proved to be ineffective replacements for paper artefacts because they lacked sufficient micro-mobility. For instance, in a medical consultation, the paper medical record could be physically moved about in various ways and shared with the patient when necessary, while the electronic medical record could only be used on the desktop computer and was clearly not as flexible. Similarly, in a construction site context, the paper allocation sheet – used to record information about workers’ progress – could be easily shared between the construction site foreman and his workers. Its flexibility was difficult to replicate using an electronic system on a notebook computer. Thus, the foreman’s work activities were radically changed

when an electronic system was introduced, reducing the foreman's mobility around the site and disturbing the previously seamless interaction he had maintained with his colleagues. I will discuss this study further in Chapter 3.

The studies described above suggest that mobile working practices vary greatly across domains. The key requirement, then, for mobile technologies appears to be flexibility – the flexibility to vary the type of access to people and information depending upon the circumstances, and the flexibility to support different mobile working practices. As described above, current PDAs can be used to support a range of activities, and with the addition of wireless communication capabilities, the PDA has become an archetypal mobile technology that seeks to provide users with access anytime, anywhere. The PDA also appears to have a high level of micro-mobility as defined by Luff and Heath (1998). It is perhaps surprising then that, given the current interest in mobile working practices and the use of mobile technologies to support them, few studies have actually examined how people use PDAs to support their everyday work activities. Indeed, Heath and Luff (2000) reported that few workplace studies have examined the mundane activities that occur in the context of people's day-to-day working lives, and the tools and objects that feature in those activities. Instead, according to Heath and Luff, such studies have generally been concerned with more substantive issues. The research described in this thesis, however, aims to understand how a personal technology such as the PDA comes to be integrated into users' everyday work activities. In the discussion below I present an overview of other research that has explored the use of PDAs in various workplace contexts.

2.2.2. Research into the use of PDA's in the workplace

There have been relatively few studies which have examined the use of PDA's as workplace tools, particularly with respect to their role in the day-to-day work activities of their users. Geisler (2003) has attempted to address this gap with an analysis of her own use of Palm technologies to support her time and information management activities. However, this study primarily examined Geisler's use of desktop Palm technologies (that is, the management software on the desktop computer that can be synchronised with the PDA). For Geisler, these tools were used to support a range of her daily activities. She used email to coordinate many workgroups and meetings, and over the course of a typical morning made many changes to her work diary and to-do list.

Geisler provided an illuminating review of the events that had led her to adopt the PDA. She had previously used a wide selection of paper and electronic tools to help her manage her time, plan work, and keep a record of her commitments. However, as her work evolved from primarily academic work – such as research and report-writing – to a more managerial role, while at the same time her children were involved in a greater number of activities that she needed to coordinate, she found that the time management tools she used were insufficient. The electronic system lacked portability, while paper diaries could not be easily shared with secretaries and other colleagues. The Palm PDA was portable, but it could also be synchronised with the electronic diary on the desktop computer, enabling Geisler to continue sharing her diary with colleagues. Thus, the PDA overcame limitations of existing tools.

Blandford and Green (2001) also examined the use of time management tools in an academic setting in their interview study of 16 staff members from a university computer science department. The focus of their research was not on the PDA alone but on the suite of tools and technologies that participants used to support their time management, including a shared electronic system. In fact, only three of their interviewees used a PDA. All participants used a wide range of tools (not just one tool in isolation), and they had each developed their own idiosyncratic ways of using those tools. For instance, some interviewees said they relied on memory for certain events, such as weekly lectures, whereas they used the electronic reminder for other events, while others used physical objects (such as piles of paper) as reminders of work to be done. Participants also found that some tasks (such as scheduling meetings) worked well on the shared electronic system, whereas others (such as planning ahead) were better suited to paper tools. One PDA user said he found it difficult to see the “big picture” on the PDA diary (p. 221).

Geisler and Golden (2003) also conducted an interview study focusing on how people used their PDAs as time and information management tools, although this was not limited to use within a workplace context. One of the most salient findings of this study was that the Palm traversed work and home boundaries. It was used to support management tasks in participants’ work and personal lives, suggesting that the common perception of the PDA as a business tool for the mobile professional does not fully capture how it is actually used across work and home settings.

Other researchers have examined the use of PDAs as data collection tools in work settings that involved varying levels of mobility (Pascoe, Ryan, & Morse, 2000;

Spain, Phipps, Rogers, & Chaparro, 2001). For instance, Spain et al developed an application to be used by workers from a “Kinesiology and Sport Studies” institute whose task was to assess the risk of physical disability in older patients. To assess this risk, the practitioner would observe the patient carrying out a range of physical activities, recording data on paper. At the end of the assessment, the observation data would be entered into an electronic database. Spain et al aimed to replace the paper system with a Palm PDA application. Their initial evaluations, which involved observing the assessment team using the PDA, suggested that the system they designed was successful. Practitioners were able to carry out the assessment as normal, recording data onto the Palm, which could then be synchronised with the desktop computer and automatically uploaded onto the database. Thus, in this context the main advantage of the PDA was the time saved because data could be recorded in electronic format and automatically transferred to the main database.

Pascoe et al (2000) also found that the PDA could be a time-saving tool when used for data collection by mobile fieldworkers. They developed an application to be used by ecologists studying animal behaviour in Kenya, who had special requirements for a portable tool that could be used to capture information quickly and accurately. The ecologists’ work was highly mobile and attention demanding. For example, Pascoe et al described a fieldworker whose job was to record the amount and type of vegetation eaten by giraffe in a Kenyan game reserve. The ecologist needed to record a range of data while also looking through a telescope and operating a stop-watch, all the while moving about in pursuit of the giraffe.

Thus, one of the requirements that Pascoe et al identified for their PDA application was that it would have a “minimal attention user interface” that would not detract attention from the fieldworker’s observation activities, enabling the user to enter data single-handedly, preferably without looking at the screen. The application they developed was tested in the field by an ecologist, who replaced her paper notebook with the PDA for a two-month fieldtrip. While the evaluation highlighted aspects of the design that needed further work, Pascoe et al reported that, overall, the trial was a success. The PDA enabled the ecologist to “complete more work, in a way that was both faster and easier” than the traditional paper-based method (p. 424). Thus, for Pascoe et al, the PDA proved to be a valuable tool for supporting the work activities of highly mobile fieldworkers.

The studies reviewed here cover a broad spectrum of workplace activities that the PDA can be used to support, from a personal account of the PDA as a time and information management tool (Geisler, 2003), to an exploration of the potential for the PDA to support animal observations in the Kenyan jungle (Pascoe et al, 2000). The research described in this thesis is closer in content to Geisler’s account and the interview studies described by Blandford and Green (2001) and Geisler and Golden (2003). Two case studies in this thesis explored the use of PDAs as workplace tools. In the first (Case Study B), the PDA was used as a generic tool by academic staff in a university department. The results from this study will be reported in Chapters 5 and 6. In the second (Case Study C), the PDA was used by mobile professionals in a large international organisation. The findings from this study will be reported in Chapter 7. Meanwhile, Case Study A examined the use of the PDA as a learning tool. The background to this research is described further below.

2.3. PDAS AS LEARNING TOOLS

In recent years, mobile learning has received much attention in the field of educational technology. New annual conferences have been established which aim to explore the virtues of mobile learning (also called *m-learning*), and some educational technology journals have dedicated special issues to the theme (e.g., Hoppe, Joiner, Milrad, & Sharples, 2003). There are also many mobile learning projects currently ongoing, such as *MOBILearn*, a European-wide venture that aims to create a mobile learning system for supporting diverse types of learning (Taylor, 2003), and the *m-learning project*, co-ordinated by the UK's Learning and Skills Development Agency, which seeks to use mobile technologies to teach basic literacy and numeracy skills to young adults (Collett & Stead, 2002). Similarly, in the United States, the Palm Education Pioneers program has provided hundreds of students and teachers in schools and colleges with Palm PDAs, exploring the possibilities these tools provide in different learning contexts (Crawford & Vahey, 2002).

The concept of mobile learning, then, is closely linked to the use of mobile technologies to support learning, leading some to suggest that m-learning is a new educational domain. However, as described below, learning has always been a mobile activity supported by the use of a variety of portable tools such as books and pen and paper. Before embarking on a review of the use of PDAs as learning tools, then, the following section seeks to unravel the concept of mobile learning and arrive at a definition of learning that is relevant to this thesis.

2.3.1. Mobile and lifelong learning

Alan Kay, one of the earlier advocates of the use of portable computing technologies in education, argued that educational technologies should be mobile because children and learners are mobile (Kay & Goldberg, 1981). Indeed, many of the more traditional technologies used to support learning – such as pen and paper, calculators, and books – are already portable. Kay was motivated to design the first handheld computer, the Dynabook, because he wanted to make computing technologies accessible for children and useful in an educational context: “I realized that if you’re making something for kids, you have to make it portable ... [so] I started sketching the Dynabook” (Shreiner, 1998). The Dynabook was developed at the Xerox Palo Alto Research Center (PARC) in the 1970s (Kay & Goldberg, 1981). However, its development did not proceed beyond the prototype phase and, for Kay, the Dynabook remains a vision for the future of learning technologies. Despite the recent success of laptop and handheld computers, Kay has argued that these tools do not support learning activities in the way that he had envisaged for the Dynabook. He had hoped that computer technologies would foster independent learning; that is, encourage students to create their own computer applications and facilitate “the ability to explore and test multiple points of view” (Kay, 2003).

Building on Alan Kay’s vision, Sharples (2000) likened mobile learning to the concept of lifelong learning, arguing that learning can take place at various points over a person’s lifetime, and is not confined to the classrooms or lecture halls of formal educational institutions. Therefore, according to Sharples, the design of personal technologies to support lifelong learning should aim to facilitate “anytime, anywhere” learning. Sharples’ framework for the design of personal lifelong

learning technologies is informed by a sociocognitive approach to learning. Elsewhere he has described this approach as an emphasis upon the “three Cs” of effective learning – construction, conversation and control:

Effective learning involves constructing an understanding, relating new experiences to existing knowledge. ... Central to this is conversation, with teachers, with other learners, with ourselves as we question our concepts, and with the world as we carry out experiments and explorations and interpret the results. ... And we become empowered as learners when we are in control of the process, actively pursuing knowledge rather than passively consuming it. (Sharples, 2003, p. 506)

Thus, for Sharples, it is important that mobile learning technologies can be used to facilitate the active construction of knowledge and to enable ongoing conversations between learners, their peers and their teachers. Such technologies, he argued, could prove to be effective lifelong learning tools.

In this thesis, the use of PDAs as learning tools is examined with respect to two specific learning activities: reading course materials (Case Study A – Chapters 5 and 6) and visiting a museum (Chapter 8). Both of these might be described by some as the passive consumption of knowledge. However, I would argue that both activities are examples of learning that takes place through construction and conversation, and is in the control of the learner. When reading for learning purposes, learners often actively engage with the text, thereby exerting control over the learning activity. For instance, they may choose to read particular sections of text, highlighting points of interest, writing notes in margins, and summarising the text (Marshall, Price, Golovchinsky, & Schilit, 2001; O'Hara, Smith, Newman, & Sellen, 1998). In this sense, learners both construct the knowledge they glean from the text as well as converse with the text itself.

Learning in the context of visiting a museum is a more informal “free-choice” learning activity (Falk & Dierking, 2000). Learners may actively choose to view particular works and find out more about the artefacts on display – in other words, they are in control of the learning activity. They may also take part in conversations with other museum visitors and, when viewing information about the works on display, they converse with the museum curators. Thus, both these activities could be considered examples of learning that incorporates the “three C’s” of construction, conversation, and control.

Furthermore, at the heart of each of the case studies in this thesis is the notion that tool use is an inherent part of any learning activity. This notion is central to sociocultural theories of learning and human activity:

Human learning has always been a matter of mastering tools of different kinds, intellectual (such as, for instance, becoming competent in how to do a division or a multiplication by using algorithms) as well as physical (learning how to build a house or how to cultivate land). A fundamental assumption in a sociocultural understanding of human learning is precisely this: learning is always learning to do something with cultural tools (be they intellectual and/or theoretical). This has the important implication that when understanding learning we have to consider that the unit that we are studying is people in action using tools of some kind The learning is not only inside the person, but in his or her ability to use a particular set of tools in productive ways and for particular purposes. (Saljo, 1999, p. 147)

The definition of learning used in this thesis, then, draws on both Saljo’s (1999) and Sharples’ (2000) views. That is, learning is perceived to be a lifelong (and therefore mobile) process, not confined to formal education, and it involves the use and mastery of tools. Therefore, an important part of educational research is to explore how people use various tools to support their learning activities. This is a major

concern for researchers working in the field of mobile learning. The “new” domain of mobile learning refers to the use of portable communication and computing technologies, such as handheld computers, mobile phones and PDAs, to support learning activities (Hoppe et al., 2003). It is, after all, only in recent years that such tools have become widely available and that researchers have begun to explore their potential uses in educational contexts. The following discussion, then, charts some of the uses that have been made of PDAs in both formal and informal learning contexts. The discussion is divided into three subsections: (1) the use of PDAs in (and outside) the classroom, (b) content delivery on PDAs (including a discussion of “e-book” materials), and (c) the use of PDAs as informal learning tools.

2.3.2. PDAs in (and outside) the classroom

Personal computing began life in the early 1980s in the form of the desktop computer. The potential educational uses of the computer have since been widely debated. Many have called for the widespread use of computers in education, while others have countered that such widespread use is impractical given the expense and encumbrance of desktop computers (Soloway et al., 2001).

As Soloway and colleagues (2001) argued, the desktop computer cannot really be classified as *personal* when used in formal educational settings, because it is typically shared amongst many students and teachers. In many schools, the bulk of the computers are located in separate computer labs, isolated from the main setting of the students’ day-to-day activities. Several authors have argued that PDAs or handheld computers could overcome the limitations of desktop computers in the classroom (e.g., Curtis, Luchini, Babrowsky, Quintana, & Soloway, 2002; Roschelle, 2003; Soloway et al., 2001). PDAs are much cheaper than desktop and laptop

computers and could feasibly be provided to each student in a class (Soloway et al., 2001). Furthermore, the portability of PDAs makes them truly personal and accessible. Their portability also means they can be used outside the classroom; thus, they could be useful for supporting fieldwork and other outdoor learning activities.

For example, Hennessy (2000) described a study in which secondary school students were given *Pocket Book* computers to use on a collaborative project that took place both inside and outside the classroom. The Pocket Book was an early handheld computer, manufactured by Psion and aimed at the education market. In this project, each student used a Pocket Book to record weather pattern data and prepare graphs. Although students worked together in small groups, they each had access to their own learning materials on the Pocket Book; thus, they maintained a sense of personal ownership over the data and project. Students collected data from a variety of sources, using the Pocket Book in many different locations. It is unsurprising, then, that they rated *flexibility and use outside classroom* as the greatest benefit of using the palmtop computer.

Sharples and colleagues have developed a handheld learning resource (the *HandLeR*), designed to support students' learning activities outside the classroom (Sharples, 2000; Sharples, Corlett, & Westmancott, 2002). The tool was equipped with a digital camera and wireless communication technologies, so students on fieldtrips could capture images and share them with other students or teachers. The intention was to enable children to "capture learning events in the field, to annotate, share and organise them into resources for learning, and to communicate directly

with other learners or teachers” (Sharples, Corlett et al., 2002, p. 221). In an initial trial, students working in small groups used the HandLeR successfully to undertake a school fieldwork project that involved exploring, and answering questions about, the local canal network.

Many other researchers have also explored the use of PDAs as collaborative learning tools for school fieldwork projects. For example, Curtis and colleagues described a school class that used iPAQ handheld computers with access to the school’s wireless network. In this setting, the PDAs were used as “inquiry-based scientific research tools” for assignments that each lasted several weeks. Using the wireless network, students could “go online and find information from wherever they [were] in the school area – whether [they were] outside collecting science data or in the cafeteria discussing questions over lunch” (Curtis et al., 2002, p.28).

In other settings described by Curtis et al, PDAs were used to support classroom collaborative learning activities by “beaming” information through the PDA’s infrared port. For instance, students in one lesson worked in pairs and took turns writing multiplication problems on their PDAs, which instantly appeared on their partner’s PDA who then attempted to solve the problem. When there were discrepancies between the answers the students gave, they discussed the problem until it was resolved. In another classroom, the PDAs were used on a daily basis for most classroom activities. At the beginning of each lesson, assignments would be beamed around the classroom from one PDA to another in a process the teacher called “cascade beaming.” Students worked in groups on each assignment, but recorded their answers individually, directly into their PDAs. Notes to be sent home

to parents were also beamed to the students' PDAs, and students used the infrared connection to print out their work on the classroom printer.

In a similar study, Davis (2003) examined the use of handheld computers that were connected to a classroom network. Students used the handhelds to record their answers to the mathematical problems set by the teacher. Through the network, the answers were collected, aggregated, and displayed for class discussion. Crucially, the answers were not linked to individual students. Thus, the class could discuss correct or incorrect answers without knowing who had got the answers wrong. According to Davis, this freed class discussion and made students more willing to talk about the answers than they might otherwise have been.

2.3.3. Content delivery on PDAs

There has also recently been much interest in the use of PDAs for accessing learning materials and information resources, particularly in the higher education sector. For instance, many colleges and universities in the United States have taken part in the Palm Education Pioneers project, providing students with Palm PDAs that can be used, for example, to connect to campus networks, or to download and store essential information resources – such as medical students' textbooks, or legal students' case notes (PalmOne, 2004a, 2004b).

The use of PDAs to store essential information resources has become particularly prominent in the context of medical education and practice (Smordal & Gregory, 2003). For instance, Sharples and colleagues designed a learning tool for trainee radiologists that provided trainees with a database of images, used to enhance diagnostic skills (Sharples, Jeffery et al., 2002). Following initial studies of the

intended users, the authors reported that self study formed a much smaller part of the trainees' activities than had been intended by the curriculum designers. Therefore, it was considered important that the new learning resource be accessible "anytime, anywhere" so that trainees could fit their study around other activities. A key requirement, then, was that the system be designed for use on a handheld computer.⁴

Medical students and practitioners need to have constant access to up-to-date information while on the move – for example, when working in a hospital (Hov, 2002). Recognising this need, in 2001 researchers at the University of Oslo supplied PDAs to medical students as they underwent practical training at hospitals and general practitioner (GP) surgeries across southern Norway (Lundby, 2002). Students were provided with an "e-book" version of their main reference text, which was stored on the PDA. They were also able to use email and to download material from the Internet when connected to a desktop computer or through the wireless networks that were installed in residential accommodation, hospital and GP settings. The intention was to provide students with "just-in-time" access to information resources, enabling them to carry all of the information they required which they could then refer to when and where it was needed (for example, while assessing a patient, when working collaboratively with other students, or while writing up case notes about their practical work experience).

⁴ However, the first prototype of this system was offered to users in versions suitable for both pen tablet computers and desktop computers, and the participants preferred to use it on a desktop computer at home. It appeared that participants did not want the burden of carrying around the portable tablet computers, despite portability having been specified as a key requirement for the system (personal communication with Sharples, 2004).

However, the study revealed that students rarely used the PDA. In fact, some students did not carry the PDA with them at all, preferring instead to use other resources such as paper artefacts, desktop computers, or to consult experienced practitioners for advice (Kasbo, Gallis, & Herstad, 2002). Some of the complaints about the PDA included its small size, limited battery life, awkward means of entering text, and an unstable network connection. This was due, in part, to the use of prototype technologies that were prone to breakdowns. In the project report, one student explained why he preferred the paper textbook to the e-book version: “Tables and figures were distorted, and due to the screen size the pages were small and numerous. This made navigation complicated. It is hard to compete with the neatly organised index of a traditional handbook in any case” (Hov, 2002, p. 16).

This is a common finding in research that has compared the use of electronic text with paper documents. Users familiar with paper documents can “flick” back and forth within the document and remember the location of important material. In contrast, electronic text contains different contextual clues and is not physically malleable like paper. Therefore, it is more difficult to navigate (Dillon, 1994; O'Hara & Sellen, 1997).

Nevertheless, there has been much interest in recent years in the use of e-books as learning materials (e.g., Adler, Gujar, Harrison, O'Hara, & Sellen, 1998; Bellaver & Gillette, 2002; Kukulska-Hulme & Pollard, 2003; Marshall et al., 2001). E-books can be broadly defined as any book-length documents (e.g., manuals, textbooks, novels) presented in digital format, whether they are read over the Internet, on desktop computers, on PDAs, or on dedicated e-book readers. The latter are

handheld devices about the size and weight of a single hardcover book (larger and heavier than a PDA), which can be used to store and read large amounts of electronic text (Schilit, Price, Golovchinsky, Tanaka, & Marshall, 1999). Although some authors have begun to assess the use of e-book readers in educational and collaborative work contexts, e-book readers are yet to gain widespread market success.

However, e-book reading software is widely available for use on PDAs. Therefore, examining the use of PDAs as tools for reading electronic text is a timely research concern. Furthermore, most of the educational uses of PDAs described so far in this discussion have involved reading some form of electronic text, regardless of whether or not it involved the use of e-book reading software. For instance, the projects described by Curtis et al (2002), which included administering class assignments, completing mathematical problems, and undertaking lengthy investigative projects, all involved reading electronic text on the PDA. The more salient example of the University of Oslo's project (Lundby, 2002) reinforces the importance of research to evaluate the usefulness and usability of PDAs for accessing course materials. In this thesis, Case Study A addresses this concern. As outlined in the previous chapter, this study examined the use of PDAs as tools for reading course materials by students on an Open University course. The findings from this study will be described in Chapters 5 and 6. Meanwhile, as outlined in the following section, the final study for this thesis observed the use of PDAs in a more informal learning setting: in an art gallery.

2.3.4. PDAs as informal learning tools

In the preceding discussion I reviewed the use of PDAs as learning tools in formal educational settings. However, as Sharples (2000) highlighted, portable technologies such as PDAs could also be useful learning tools in more informal settings, supporting lifelong learning that takes place both within and outside formal education. Some recent projects have begun examining the use of PDAs in various learning contexts outside the formal education system. For instance, Wood and colleagues described a project (then in the planning stages) in which PDAs were to be given to breast cancer patients and used to access information relevant to the patient's hospital care (Wood, Price, Laird, & Robertshaw, 2002). Similarly, Rogers (2002) suggested that mobile technologies could be useful for supporting the information needs of pregnant women. Meanwhile, in an attempt to engage disaffected youths in learning activities, Collett and Stead (2002) developed educational games and resources to be delivered on mobile phones and Pocket PCs as part of the m-learning project. The learning activities they described were designed to help young people set up their own home and become independent, teaching them about tenancy agreements and how to manage finances. Another resource used text and video to inform participants about the rules of football refereeing, in order to prepare them for a short course leading to a qualification. The intention was to improve participants' literacy and numeracy skills in the context of the problems and challenges faced by young people who were most at risk of social exclusion.

The use of PDAs as informal learning tools has perhaps received the most attention in the context of visiting museums and art galleries (Fleck et al., 2002; Hsi, 2003;

Proctor & Burton, 2003; Proctor & Tellis, 2003). In such contexts, the PDA is not really a personal tool. Rather than owning the PDA, the user borrows it from the museum for the duration of the visit. The PDA can then be used to access information relevant to the artefacts on display. For instance, in the Tate Modern gallery in London, PDAs are being used to deliver multimedia content that contextualises the work on display, using a combination of video (e.g., images of the work being created), audio (e.g., interviews with artists), communication facilities (e.g., the option to send text messages to other museum visitors), and interactive games (Proctor & Burton, 2003; Proctor & Tellis, 2003). This context formed the focus of the final study for this thesis, and will be described further in Chapter 8.

In other studies, PDAs have been used by visitors to the Exploratorium museum in San Francisco (Fleck et al., 2002; Hsi, 2003). In their observations, Fleck et al found that PDAs were “too large and fragile for users who want[ed] to experiment with the exhibits,” and the combination of several functions on the PDA made it too complex (p.18). Therefore, they chose to focus on one function – remembering information about the exhibits – and provided this on a handheld “tag” that could be swiped against the exhibit to “bookmark” the relevant information. This study will also be described further in Chapter 8.

As this review has demonstrated, the use of PDAs as learning tools has been widely explored in recent years. PDAs have been used as collaborative learning tools in the classroom, as tools for supporting student fieldwork, as devices for accessing information resources while on the move, and as informal learning tools in settings such as museums and art galleries. With the exception of the University of Oslo’s

medical student project, most of these studies have been overwhelmingly positive in their evaluations of the potential benefits that PDAs offer as learning tools. However, the following section cautions against such “pro-innovation bias” (Rogers, 1995). In the following discussion I will describe a more balanced approach, taking into account both the possibilities and constraints that a new tool introduces, that will form the basis of the studies reported in this thesis.

2.4. A NOTE ON THE “PRO-INNOVATION BIAS”

In his extensive review of the literature on the diffusion of social and technological innovations, Rogers (1995) warned that many of the studies he surveyed contained a pro-innovation bias. That is, the authors of the research assumed the innovations they were studying would offer great benefits to the people who were given the opportunity to use them. Innovation adoption was always therefore seen to be a desirable outcome, and studies rarely focused on the nonadoption of new technologies and practices. Thus, according to Rogers, many of these studies did not offer a balanced view of the benefits and limitations of the innovations being studied.

This pro-innovation bias can also be seen in many technological deterministic approaches, which Mackenzie and Wacjman (1985) warned against. For Mackenzie and Wacjman the main limitation of technological determinism was its tendency to focus on the impact of technology on society while ignoring the many societal influences that can shape technology. Many authors whose research could be described as technologically deterministic have suggested that new technologies will *revolutionise* society in many positive ways. This attitude is particularly prevalent amongst educational technologists who believe that new technologies will radically

improve education and change learning for the better (e.g., Roschelle, 2003; Soloway et al., 2001).

Although Mackenzie and Wacjman might disapprove of such beliefs, these predictions do have a strong basis in historical events. For instance, it is widely acknowledged that the invention and diffusion of technologies such as writing and the printing press radically changed the way people communicated and used information, often for the better (Kay, 2003; Saljo, 1999). There is a place, then, for the enthusiasm that some commentators display when talking about the potential benefits of new technologies. Many technologies could change the way people work and live in various positive ways, and the drive to instigate this change could help drive the development of new technologies (as seen in the example of Alan Kay's Dynabook, and Jeff Hawkin's PalmPilot).

However, there is also a need for more realistic and balanced studies of what Churchill and Wakeford (2002) called the "consumption" of new technologies. Churchill and Wakeford argued that idealised notions of mobile technologies have driven the development of new technologies away from a realistic understanding of how such tools are actually used. Thus, they called for research to focus more explicitly on how people actually *consume* mobile technologies:

Forms of representation like advertisements contribute to a general discourse of mobility. This generalised discourse plays into common narratives of use. Other sources of consumption that are not purposely manufactured are one's personal experiences and the experiences of others one knows or can observe. Narratives of use are also experienced through magazine and newspaper reports and through movie and television viewing. Our main point is that narratives of consumption are too often created from partial and fragmentary knowledge drawn unsystematically from multiple sources, and when applied

in the production process in similarly fragmentary ways, can produce unwarranted assumptions about desirable device functionality and device design. We believe it is fruitful to turn to more systematic and focused analyses of consumption to create a discourse of mobility and mobile device use that is more directly relevant to people's experiences. (p.164)

In this thesis I aim to present the *systematic and focused analyses of consumption* that Churchill and Wakeford have called for. In particular, the focus on the concept of *tool appropriation* is closely aligned with Churchill and Wakeford's appeal for analyses of mobile technology consumption. Analysing consumption could be seen as synonymous with examining how people appropriate new technologies – that is, integrate them into their day-to-day activities. In this thesis, tool appropriation will be examined with reference to concepts from activity theory, as described further in the next chapter.

The thesis also aims to expound the concept of *tool mediation* with reference to the impact the PDA appeared to have upon learning and workplace activities in each of the four studies. I have endeavoured to avoid the pro-innovation bias and technological deterministic views outlined above by examining both the possibilities and constraints that the PDA introduced within each of the learning and workplace settings it was used, while also looking at the sociocultural factors that influenced how the PDA was appropriated. My approach to the evaluation of the PDA as a learning and workplace tool draws on Carroll and colleagues' depiction of technology evolution, which they described as a "task-artefact cycle":⁵

The evolution of HCI technology is a coevolution of HCI tasks and HCI artifacts: A task implicitly sets requirements for the development of artifacts

⁵ I have used the UK spelling "artefact" throughout this thesis, except when directly quoting other sources that use the US spelling "artifact."

to support it; an artifact suggests possibilities and introduces constraints that often radically redefine the task for which the artifact was originally developed. (Carroll et al., 1991, p.79)

This depiction of the task-artefact cycle suggests that in order to understand how a new tool changes the activities it is used to support, it is necessary to examine both the possibilities and constraints introduced by the new tool. This approach is fundamental to the evaluation of PDAs presented in this thesis. Describing technology evolution as a *coevolution of tasks and artefacts*, Carroll et al have recognised the two-way relationship between technology and social factors, thus avoiding an overly deterministic account of technology development. However, the tasks that people undertake form only a small sub-set of the many possible social factors that can influence how a new tool is used. In the next chapter, I will describe the concept of an activity system as an alternative way of looking at the tasks people do, which is broader in scope and provides a more encompassing view of the sociocultural context in which human activity takes place.

2.5. CONCLUSION

In this chapter, I have reviewed recent research that has examined the use of PDAs as learning and workplace tools. This review included a discussion of the concepts of mobile computing, mobile working, and mobile learning, which are central to an understanding of how the PDA is perceived as a mobile technology in learning and workplace contexts. Although the PDA is widely considered to be a portable tool for mobile professionals, its use as a day-to-day workplace technology has been largely overlooked in the literature. In contrast, much recent research has examined the use of PDAs and other mobile technologies in a wide range of learning settings. However, there is a tendency within this literature for authors to display a pro-

innovation bias; thus the limitations of PDAs as learning tools are often overlooked in favour of enthusiastic appraisals of their potential benefits. This chapter has therefore concluded with a warning against such pro-innovation bias, and a pledge to avoid it in the chapters that follow. Thus, the case studies presented in this thesis aim to examine both the benefits and limitations of PDAs as learning and workplace tools.

Chapter 3

Theoretical Background

The purpose of this chapter is to describe the theoretical background to this research. In particular, this chapter will clarify some of the central concepts from activity theory, and explain how they can be used to help answer the two research questions of the thesis. To reiterate, the research questions are

- 1) how are PDAs appropriated as learning and workplace tools, and
- 2) how do PDAs mediate (and consequently change) learning and workplace activities?

These questions reflect the two central themes of this thesis: tool appropriation and tool mediation. This chapter begins with a discussion of each of these themes. This will be followed by an overview of activity theory which will explicate the central concepts from activity theory that have informed this research. These include the notions that (a) activities are sociocultural systems, (b) activities can be divided into hierarchical layers of actions and operations, and (c) all activities are in a constant state of transformation, involving the introduction and resolution of contradictions in the activity system and breakdowns in the actions and operations that make up the activity. Finally, in Section 3.4, I will link these activity theory notions to the central themes of tool appropriation and tool mediation, describing how activity theory will be used as an analytical framework in this research.

3.1. TOOL APPROPRIATION

It is widely recognised that people adapt, and adapt to, the technologies they use. The idea that people appropriate new technologies has received much attention in recent years, particularly in the sociology and information systems (IS) literatures (e.g., Brosveet & Sorensen, 2000; Carroll, Howard, Vetere, Peck, & Murphy, 2002; Mackay, 1995; Majchrzak, Rice, Malhotra, King, & Ba, 2000; Silverstone, Hirsch, & Morley, 1992). However, these two sets of literature use an array of terminology to describe the appropriation process; it has been referred to as *adaptation* (Majchrzak et al., 2000), *reinvention* (Rogers, 1995), *local improvisation* (Suchman, 2002), and *domestication* (Brosveet & Sorensen, 2000). Such varied terminology can lead to confusion. For instance, Brosveet & Sorensen used the term domestication to refer to “multimedia adoption at the national level” (p. 263). Elsewhere, however, this term has been used to refer to the way technologies become integrated into users’ domestic – that is, personal and family – spaces (Silverstone et al., 1992).

Given the confusing array of terminology and definitions in the literature, the following discussion will begin by defining tool appropriation as it is used in this thesis. I will then contrast the concept of appropriation with the more familiar concept of technology adoption, and provide a brief overview of recent attempts to model the process of tool appropriation.

3.1.1. A definition of tool appropriation

In this thesis, tool appropriation is defined as *the integration of a new technology into the user’s activities*. The term appropriation has been chosen here to signify that tool use is an active process through which users exert ownership over the tools they use.

The user is not a passive recipient of the new technology but instead chooses to use it in various unique ways, adapting her use of the technology to suit her own purposes. This understanding of appropriation builds on Wertsch's (1998) definition, which described appropriation as the process of "taking something that belongs to others and making it one's own" (p.53). The concept of ownership is particularly important when the technology in question is a personal technology such as the PDA. Given the growing interest in the use of such technologies in education and workplace settings (as reviewed in Chapter 2), understanding how users appropriate personal and portable technologies, such as PDAs, is a timely concern.

I have chosen to use the term *tool* (as opposed to *technology* appropriation) for two reasons. Firstly, this is consistent with activity theory terminology, linking tool appropriation with the activity theory concept of tool mediation, which will be described further below. Secondly, as discussed in Chapter 1, the term *tool* is preferred over *technology* because it signifies that the device in question serves a particular purpose; the purpose that the technology serves is intricately related to how it has been, and will be, appropriated. As Christiansen (1996) argued, "only in actual practice does [an artefact] become a tool. In other words, to become a tool is to become part of someone's activity" (p. 177).

3.1.2. Technology adoption

Tool appropriation is not to be confused with the more widely-used concept of *technology adoption*. Adoption refers to the decision to use a new technology, and is not concerned with how people adapt and incorporate that technology into their activities. Two influential theories of technology adoption have recently received much attention in the information systems (IS) literature, which is concerned with

identifying how new technologies can be successfully integrated into workplace settings. In particular, Davis's (1989) *Technology Acceptance Model* (TAM) has been widely used to predict whether potential users in an organisational setting will accept and adopt a new technology (e.g., Al-Gahtani & King, 1999; Gallivan, 2001). TAM identifies two main variables that are said to predict whether a person intends to use a new technology: perceived ease of use (or usability), and perceived usefulness. While these variables have been shown to be strong predictors of *intention* to use a particular technology (Davis, 1989), the model does not take into account how the technology is *actually used* in different contexts by individual users.

Rogers' (1995) *Diffusion of Innovations* theory is a broader model that is also popular amongst IS researchers and those concerned with predicting the market success of new technologies. This theory describes how new technologies (and other innovations) become widely accepted and used across organisations and social settings; thus, it is concerned with the market penetration of new products or ideas. Rogers identified categories of potential adopters, which roughly equate to the time it takes people to accept new technologies. These are "(1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards" (Rogers, 1995, p. 22). He described the diffusion process as an S-curve, whereby a small number of people (the innovators and early adopters) initially adopt a new technology, followed by larger numbers of people (early and late majority), with the curve then tapering off as the laggards finally take up the innovation. The Diffusion of Innovations theory, then, describes a linear process whereby new (or conceptually new) innovations are communicated and adopted across the adopter categories.

Although Rogers recognised that users appropriate new technologies – as reflected in his discussion of the concept of reinvention, which he defined as the “degree to which an innovation is changed or modified by a user in the process of its adoption and implementation” (p. 174) – his main concern was to describe the variables that lead to a decision to adopt a technology. According to Carroll and colleagues, this is insufficient: “we need to examine technology appropriation over time: users’ expectations, the decision to adopt and actual use” (Carroll, Howard, Peck, & Murphy, 2002).⁶

If researchers are concerned with understanding how a technology can be used effectively in learning and workplace settings, they need to consider how learners and workers actually use the technology, and to take into account the myriad of meanings users may ascribe to the tools they use (Mackay, 1995). In an attempt to address the insufficiency of technology adoption theories, Carroll and colleagues have been developing a framework of technology appropriation. This framework – along with other recent attempts to model the appropriation process – is described briefly below.

⁶ This reference refers to work by Jennie Carroll at the University of Melbourne, not to be confused with John Carroll, author of the task-artefact cycle.

3.1.3. Models of technology appropriation

The model of technology appropriation by Carroll and colleagues is drawn from their studies involving focus group interviews and observations of young mobile technology users, as well as from their research examining mobile technology use in work settings (Carroll, Howard, Peck et al., 2002; Carroll, Howard, Vetere et al., 2002; Herszfeld, Carroll, & Howard, 2003). Their framework describes technology appropriation as a three-level process. At the first level, *attractors* and *repellents* of the technology act as *filters* to the appropriation process; that is, the decision to experiment with and use a new technology is based on the user's initial evaluation of the device and the possibilities and constraints it presents. In the case of young people's mobile phone use, attractors included the convenience afforded by the technology, and whether it was considered fashionable, while repellents included the cost to purchase and use the device and, in some cases, poor usability. Carroll et al argued that if the device primarily consists of attractors rather than repellents, the decision will be made to adopt and appropriate the technology.

Then, during the second stage of appropriation, users will evaluate the technology based on how well it fits in to their lifestyles and meets their needs; that is, how well it meets the *appropriation criteria*. If this process of appropriation is successful, use of the device will continue, with the technology subjected to further evaluation and reinforcement. This does not mean, however, that use of the device is now guaranteed and stable. Over time, if the device no longer satisfies users' needs, "or a new technology becomes available that satisfies these needs more completely or closely, then the technology may be disappropriated and its use abandoned" (Carroll, Howard, Vetere et al., 2002).

The framework by Carroll and colleagues describes a series of stages in the technology appropriation process. It does not, however, examine the sociocultural factors that may influence how new technologies are appropriated by individual users. Another attempt to model technology appropriation comes from IS researchers using structuration theory to explain “technology adaptation” (DeSanctis & Poole, 1994; Majchrzak et al., 2000). DeSanctis and Poole’s “adaptive structuration theory” examines how organisational structures are changed through the adaptation of information technologies for use in group work settings. Their model shows three major influences over the adaptation process: (1) the technology’s structural features and “spirit” (i.e., the designers’ intent embodied in the technology), (2) task and organisational structures, and (3) the work group’s internal structure (Majchrzak et al., 2000). Therefore, unlike the framework by Carroll et al, this model emphasises the importance of the context into which a new technology is introduced, and argues that features of that context – or, in the authors’ terms, the existing structures within the organisation – will feed into the appropriation process. However, one major limitation of this model is that it relates explicitly to organisational settings and refers primarily to the use of information technologies by collaborative work groups, assuming that appropriation is a group decision. It does not, then, relate to the appropriation of personal technologies by individual users who may or may not be using the technology for collaborative purposes.

Furthermore, DeSanctis and Poole (1994) argued that in order for the benefits of a new technology to be realised, users’ appropriations should match the “spirit” of the technology; that is, users should appropriate the new tool in the way the designers

had intended. Therefore, users' adaptation of a technology was seen as an undesirable outcome, a deviation from how the technology should be used. In contrast, Carroll (2004) argued that technology appropriation is an important part of the design process. She suggested that it should be encouraged by those responsible for designing and implementing new technologies, and that understanding how users appropriate a particular technology could be a useful way of furthering design:

The challenge for designers is to design malleable technologies that can be adapted to users' organisational, social and personal practices, and then to harvest users' needs from the appropriated innovation in order to improve its design. For managers, trainers and IS staff involved in the implementation of innovations, the challenge is to encourage and support users' appropriation activities. (p. 1)

In this thesis, tool appropriation is assumed to be both a necessary and desirable process. In order for people to use new technologies productively, they must appropriate those technologies to suit their particular purposes. By appropriating a technology, the user exerts ownership over it and comes to "care for" the device; it is through this process of appropriation that the technology becomes a useful tool (Christiansen, 1996). Researchers concerned with understanding and developing the use of new technologies – such as HCI, IS, and educational technology researchers – should not, therefore, ignore the concept of tool appropriation. As Carroll (2004) argued, understanding the tool appropriation process may help technology designers and implementers make better-informed decisions. As outlined below, this thesis contributes to furthering our understanding of the process of tool appropriation by examining the sociocultural factors that influence this process through an activity theory analysis. This approach is introduced briefly below, and described further in Section 3.4 of this chapter.

3.1.4. A two-way process of tool appropriation

The *Activity System Tool Appropriation Model* developed in this thesis (described in Section 3.4) differs from the models described above in that it focuses more explicitly on understanding the sociocultural factors that influence how people appropriate the tools they use. This model draws on activity theory to describe and explain these influences. The aim to understand how tool appropriation is shaped by various social influences is similar to the concern within the field of sociology to understand the social shaping of technology design and development. However, as Mackay (1995) argued, understanding the social factors that influence technology design does not fully account for the social shaping of technologies:

A focus on the socially shaped development and production of technology is incomplete because it fails to consider the social forces at work on the other side of the technology: the way that technologies come to be actively appropriated by their users. [...] People may reject technologies, redefine their functional purpose, customize or even invest idiosyncratic symbolic meanings in them. Indeed they may redefine a technology in a way that defies its original, designed and intended purpose. Thus, the appropriation of technology is an integral part of its social shaping. (p. 44)

Furthermore, analyses of the tool appropriation process need to consider how new technologies fit in with the existing tools that people use, and whether the new technology can fill a niche in the user's activity. That is, it is not just a matter of understanding how new technologies fit into social systems, but also how they fit into existing technical systems. This issue is discussed later in the thesis (see Section 5.3.2).

The concern with understanding the process by which tool appropriation is shaped by social factors differentiates the ASTAM framework developed in this thesis from the

technology appropriation models described above. A further differentiation is the emphasis in this thesis on the *two-way process of tool appropriation*. This is very similar to what Brosveet and Sorensen (2000) described as the domestication of new technologies:

In general terms, what is taking place is a process where the technology and the social system under scrutiny coevolve in a process of reciprocal shaping. If the introduction is successful, the artifact becomes situated, practically and symbolically, while the social system develops routines and institutions to support and regulate it. Users will construct practices as well as meanings around the artifact that will be transformed from an alien into a recognizable element. This process may be called *domestication*. (Brosveet & Sorensen, 2000, p. 263)

In this thesis, tool appropriation is linked with the concept of tool mediation to describe this two-way process. Tool appropriation refers to the social shaping of the technology; that is, how its adaptation and use is influenced by elements of the social and technological systems into which it is introduced. Tool mediation, meanwhile, refers to the technological shaping of society. In this thesis, this refers specifically to how technologies (in this case PDAs) change the activities they are used to support. The concept of tool mediation is described further below.

3.2. TOOL MEDIATION

One of the central tenets of activity theory is the notion that all human activities are mediated by the use of tools, both conceptual tools such as language, and physical tools, such as technical artefacts. As already established, this thesis is concerned with understanding how certain technological tools (i.e., PDAs) mediate learning and workplace activities. The term mediation is used here to refer not only to how activities are conducted through the use of tools, but also to emphasise that tools

change activities. In the following discussion I will examine some of the historical background to the concept of tool mediation and report how it has been conceptualised in recent discourse. This will be followed by a discussion of how the concept of tool mediation has expanded the scope of research concerned with evaluating the use of new technologies.

3.2.1. Tool mediation: historical background

The concept of tool mediation has its roots in Marxist and German philosophy (Davydov, 1999; Wertsch, 1998). Marx's depiction of labour centred around the notion that people use tools to change and control aspects of the world:

In describing the general characteristics of human labor, Marx depicts it, first, as human activity that changes nature. *Human activity uses features of one natural object as tools for acting on other objects*, thus turning the former into an organ of activity. Exerting influence on nature, human beings change their own nature at the same time. (Davydov, 1999, p. 40; italics added)

That is, human labour involves both the development and use of tools, which are historically and culturally situated. In the 1930s, Vygotsky extended this notion of tool mediation and developed the idea that mediating tools can consist of both physical tools that evolve in relation to their use in productive labour – such as technological artefacts – and culturally-developed sign systems such as language (Vygotsky, 1978).⁷ Vygotsky was particularly concerned with understanding how language mediates thinking. He demonstrated that when children acquire language skills, their cognitive and problem-solving abilities change. Initially, children use egocentric speech to direct their actions. That is, they talk to themselves, verbalising

⁷ Although Vygotsky conducted most of his research and writing in Russia in the 1930s, his work was not translated and published in the West until the 1970s.

their plans and reflecting the world in an attempt to effectively manipulate objects and control their own behaviour. As the child internalises this speech function, the relationship between speech and activity changes:

Initially speech follows actions, is provoked by and dominated by activity. At a later stage . . . speech guides, determines, and dominates the course of action; *the planning function of speech* comes into being in addition to the already existing function of language to reflect the external world. (Vygotsky, 1978, p. 28; italics in original)

In other words, new tools change activities. Vygotsky also demonstrated that children use language to enlist the help of other people when solving problems. In doing so, the “child’s ability to control another person’s behavior becomes a necessary part of the child’s practical activity” (p. 29). Thus, for Vygotsky, practical activity is always mediated by the use of language and other cultural tools. Vygotsky went on to illustrate how language and other sign systems mediate other aspects of cognitive development, and to emphasise that communication is an integral part of human learning. However, reviewing the full extent of Vygotsky’s work is beyond the scope of this thesis. What is relevant here is that Vygotsky was instrumental in extending the notion of tool mediation from its basis in the Marxist concept of labour production and that, for Vygotsky, human activity and development could not be understood without reference to the use of tools – in particular, sign systems such as language.

One of the reasons Vygotsky emphasised tool mediation as the central component in human activity, was that the concept of tool mediation broke down the dichotomy separating “the individual mind from the culture and the society” (Engestrom, 1999, p. 29). That is, because tools are developed and used within particular social and

cultural settings, examining activity as a tool-mediated process places that activity within its sociocultural context (Cole, 1996; Wertsch, 1998). Thus, for Vygotsky, understanding tool mediation was key to linking human development to social and cultural practices:

Like tool systems, sign systems (language, writing, number systems) are created by societies over the course of human history and change with the form of society and the level of its cultural development. Vygotsky believed that the internalization of culturally produced sign systems brings about behavioral transformations and forms the bridge between early and later forms of individual development. Thus for Vygotsky, in the tradition of Marx and Engels, the mechanism of individual developmental change is rooted in society and culture. (Cole & Scribner, 1978, p. 7)

Cole (1996) extended Vygotsky's ideas to create a distinction between artefacts and tools. According to Cole, the term *tool* is limiting because it implies a physical device, whereas the term *artefact* can be used to refer to both physical tools and the sign systems, such as language, with which Vygotsky was concerned. However, it is also possible that the term artefact implies a physical object, while the term tool is more encompassing, referring – as it does – to both technical devices and more abstract entities. An arithmetic formula, for instance, could be considered a tool (Saljo, 1999). As stated in Chapter 1 (see page 5), the term tool is preferred in this thesis because it signifies that the object or device is being used for a particular purpose.

Cole's (1996) discussion of tools and artefacts does, however, offer a helpful distinction between the *conceptual* and *material* properties of an artefact/tool. Cole suggested that artefacts are “simultaneously ideal (conceptual) and material” (p. 117). They are conceptual in that their meaning is dependent on their use and the

way they have been used in the past. This idea may help clarify tool appropriation: people appropriate tools (or artefacts) by assigning meaning to them according to how they are used and integrated into the user's activities. Cole's conception of an artefact as both *material* and *conceptual* suggests that it is important to examine both the physical features of a device and the various meanings ascribed to it by its users.

As outlined at the beginning of this section, in this thesis tool mediation is closely linked to the idea that new tools change activities. This issue will be addressed in the following chapters with reference to the second research question of the thesis. My intention in examining the issue of how PDAs mediate learning and workplace activities is to also address the broader issue of understanding how activities change when new tools are introduced. There are many research fields concerned with understanding what happens when new tools are introduced into learning or workplace activities – for instance, educational technology, IS, HCI, and CSCW. Researchers within these fields are particularly concerned with *evaluating* the use of new technologies in learning and workplace settings; that is, assessing whether particular technologies are useful and usable, and determining the design requirements that might improve these qualities. These concerns are the prime drivers of HCI research (Carroll, 2003). It is in this research field that the concept of tool mediation has had the most impact, as described below.

3.2.2. Tool mediation and technology evaluation

The notion that tool mediation is central to all human activities is one of the reasons that activity theory – which will be described further below – has had such an impact on HCI, and other relevant disciplines, in the past decade (e.g., Bodker, 1991; Halloran, Rogers, & Scaife, 2002; Kaptelinin, 1996a; Nardi, 1996b; Turner &

Turner, 2001). The emphasis on tools, including computer tools, as mediators of activity focuses attention on the activity itself rather than simply the interaction between the human and the computer.

In the past decade or so, researchers within HCI have been trying to find a way of including consideration of the *context* in which computer tools are used (Rogers, 2004). Many authors have highlighted the limitations of the information processing approach which was dominant in the 1980s (e.g., Bannon, 1991; Kaptelinin, 1996b). One of the main criticisms of this approach was that the unit of analysis was too narrow, focusing as it did on isolated interactions between the computer and the user. Within this approach, evaluations of computer systems often focused on usability issues, and took place in laboratories, with participants using the computer program to carry out experimenter-defined tasks (for example, the study by Sears & Arora, 2002, which was reviewed in Chapter 2). No consideration was given to the “real-world” contexts in which those computer tools would be used.

In an effort to expand the field of HCI, many researchers have recently stressed that laboratory-based usability studies are insufficient; it is also important to design and evaluate computer systems with reference to the context in which they are used (Rogers, 2004). However, as Macaulay (2000) put it, context can be a “notoriously slippery term” (p. 35). Discussing this problem, Nardi (1996b) argued that research in HCI needs to find some balance between a “full context,” which would be too broad in scope to be manageable, and the traditional HCI approach of examining an isolated user interacting with a device. For Nardi, allowing for a consideration of

context in HCI research means “finding oneself in the thick of the complexities of particular situations at particular times with particular individuals” (p. 70).

One way of achieving this is to consider how tools are used *in activity*. This means taking into account how tools are used to achieve certain goals. However, as acknowledged in Chapter 1, tools are not always used in goal-directed activity; they can also be the object of playful activity, known as *bricolage* (Levi-Strauss, 1966). When used in this way, they might help the user identify new goals or objectives that could be achieved with the technology. However, the main concern of this thesis is not to understand the role of tools in bricolage activity, but to understand how PDAs are used as mediating tools in objective-driven learning and workplace activities. In other words, this thesis is concerned with understanding the process by which new tools mediate activities.

The activity theory notion of tool mediation is typically illustrated by the triangle presented in Figure 3-1, which derives from Vygotsky’s work. According to this figure, the relationship between the person (subject) and the goal (objective) of the activity is not direct: it is mediated by the use of tools. Therefore, the minimum context that needs to be considered when evaluating how a particular tool is used consists of the user and the user’s goals. Thus, in the tool mediation triangle the human is seen to be doing something other than using the computer: the computer is the tool through which the user achieves her objectives. According to this perspective, then, evaluation of computer artefacts should focus not only on identifying usability issues, but also on examining how well the tool supports the

user's activities. As Bannon and Bodker (1991) put it, "*a tool is what it is used for*" (p.238; italics in original).

Activity theory has a lot more to say about context. Engestrom (1987), for instance, has expanded the tool mediation triangle to include a framework that describes the social setting in which activities take place. This framework, and other activity theory concepts, will be described further in the following section.

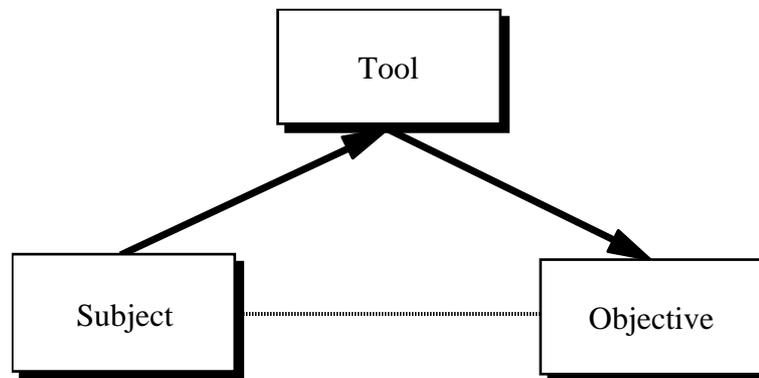


Figure 3-1. The activity theory tool mediation triangle

3.3. ACTIVITY THEORY

In the previous section I introduced one of the central tenets of activity theory – the idea that all human activity is mediated by the use of tools. In this section I will introduce further central concepts from activity theory that are relevant to this research. These can be summarised as follows:

- a) Activities are sociocultural systems consisting of the subject (or person) acting on the object (goal) of the activity through mediating tools within a community governed by rules and a division of labour.
- b) Activities can be divided into hierarchical layers consisting of actions and operations.
- c) Activities are in a constant state of development and transformation.
- d) Actions and operations are not static but evolve over time.
- e) Contradictions within and between activity systems drive the development of those activities.

The latter two points will be used in my analysis of how PDAs mediate learning and workplace activities (Chapter 6), while the first point – that activities are sociocultural systems – will be used to determine how sociocultural factors influence tool appropriation (Chapter 5). Before describing these concepts in greater detail, however, I will first provide a brief introduction to activity theory.

3.3.1. Activity theory – an introduction

Activity theory emanates from Marxist philosophy and Soviet psychology, and has evolved from decades of theorising based on these traditions. At the root of activity theory is Marx's dialectical materialism, which was described by Macaulay (2000) as follows:

[Dialectics] came to refer to the unification of opposites, as is expressed in three dialectical principles (Bakhurst, 1991): the interconnectedness of things, the constancy of change and development, and development as the result of the resolution of contradictions inherent in all things. (Macaulay, 2000, p. 33)

Marxist ideas were incorporated into Soviet psychology by Vygotsky and his colleagues. Vygotsky is often considered the founding father of activity theory, although he did not develop the full set of concepts known today as activity theory (Wertsch, 1985). Instead, one of his students, Aleksi Leont'ev (1978) was

instrumental in developing Vygotsky's ideas into a theory of activity. In this version of activity theory, activity is divided into hierarchical layers of actions and operations. Developing these ideas further, Yrjo Engestrom (1987) set out another version of activity theory, describing activity as an expansive social setting under constant transformation. Engestrom's activity system framework (described further below) builds on the Marxist concept of contradictions that drive the development of social systems. Engestrom's framework has been applied in workplace and educational research and is widely accepted as the current version of activity theory. Many Scandinavian and North American researchers have also recently incorporated versions of activity theory – based on both Engestrom's and Leont'ev's ideas – into HCI research (e.g., Bodker, 1991; Kaptelinin, 1996b; Kaptelinin, Nardi, & Macaulay, 1999; Kuutti, 1991, 1996; Nardi, 1996a).

One of the main criticisms of using activity theory as a framework for evaluating new technologies is that it is highly complex and difficult to learn (Rogers, 2004). One reason for this is that the many writings that contribute to activity theory as it is recognised today have undergone various translations, having originated in Russian, German and Scandinavian languages. This has led to different conceptions of familiar terms. For example, Kuutti (1996, p.41) noted that the German and Russian equivalent of the term *activity* has connotations of “doing in order to transform something” and it is this sense of the term that forms the basis of activity theory: all activities involve transforming an object into an outcome.

Similarly, the notion of an object does not just mean a physical object as it is generally understood in English. Rather, it also encompasses the concept of an

objective (Nardi, 1996b, p.73). That is, the object represents the motive of the activity.

A further barrier to the use of activity theory is that it is not a theory as such in that it is not “a fixed body of accurately defined statements” (Kuutti, 1996, p.25). Rather, it is a collection of broadly defined concepts that are themselves under constant development and modification (Engestrom, 1993). Thus, activity theory is open to interpretation, and the description presented here is my interpretation of those key concepts that are particularly relevant to my research and helpful in providing an explanatory framework for the data.

The flexibility of the activity theory approach presents both advantages and potential limitations. On the one hand, it means that activity theory can be adopted by researchers in various disciplines, and has been employed as an analytical framework in fields such as educational technology (e.g., Bellamy, 1996; Issroff & Scanlon, 2002), workplace studies (e.g., Engestrom, 1993), and information systems design (e.g., Bodker, 1991; Turner & Turner, 2001). The broad appeal of activity theory is particularly beneficial to a multi-disciplinary field such as HCI.

On the other hand, however, the fact that much of activity theory is open to interpretation means that it may be utilised in quite disparate ways by different researchers. Furthermore, activity theory does not offer an explicit set of procedures to guide research (Nardi, 1996a). Although there have been some attempts to extract a set of research methods from activity theory (Kaptelinin et al., 1999; Mwanza, 2002), such methods were developed in research settings with specific objectives,

and therefore may not be applicable to other research activities. Rather, it seems appropriate, as Engestrom (1993) argued, to *concretize* activity theory in line with the particular research activity that is taking place:

Activity theory is not a specific theory of a particular domain, offering ready-made techniques and procedures. It is a general, cross-disciplinary approach, offering conceptual tools and methodological principles, which have to be concretized according to the specific nature of the object under scrutiny.
(Engestrom, 1993, p. 97)

Thus, the concepts presented here, and my interpretation of them, represent an attempt to concretize activity theory for the purposes of the present research. In the discussion that follows, I will describe those activity theory concepts that have informed my research.

3.3.2. The activity system

In activity theory terms, an activity – as well as being a process that transforms an object into an outcome – is also defined as a *social system*. In this sense, activities involve communities of people and are embedded within particular social settings. This idea is typically illustrated by Engestrom's (1987) *activity system triangle* (Figure 3-2). Engestrom's model incorporates the basic tool mediation triangle shown in Figure 3-1. That is, it includes the *subject*, or person acting on the world, the *object* towards which the activity is directed (representing the activity's motive) and the *tools*, through which the activity is mediated. Engestrom added to this basic triangle three further components: the *community*, *rules/regulations* and *division of labour*, which each have a mediating role in the execution and development of the activity.

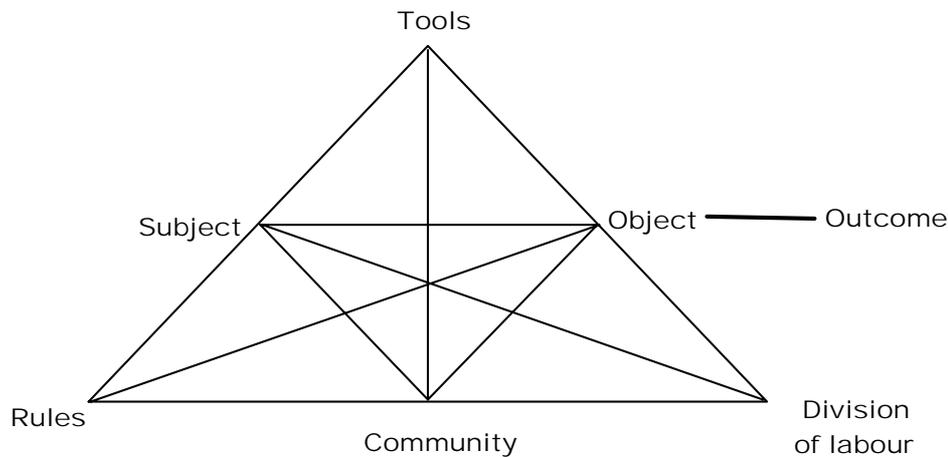


Figure 3-2. Activity System Triangle (adapted from Engestrom, 1987)

The **object** (in the sense of *objective*) is what drives the activity (Nardi, 1996b). This is the motive or goal towards which the activity is directed, and it distinguishes one activity from another. The object can be either a physical thing (such as the examination paper when taking part in a school exam) and a more general motive or idea (such as the desire to become educated). Through activity, the object is transformed into an outcome.

There is some ambiguity in the activity theory literature as to the distinction between the **subject** of the activity (or the actor) and the **community**. According to some authors, the subject can be either an individual or a *collective subject*, that is, a group of individuals who share the same object of the activity (e.g., Halloran et al., 2002). However, the community is also sometimes defined as “those who share the same object” (Kuutti, 1996, p. 27). In this sense the subject and the community represent the same component in the activity system. According to Engestrom (1993), the definition of the subject as an individual or a group depends upon the research

object: “the *subject* refers to the individual or subgroup whose agency is chosen as the point of view in the analysis” (Engestrom, 1993, p. 67). For the purposes of clarity, therefore, I will refer to the subject as an individual (not a collective subject) who actively participates in an activity system.

Such an approach, however, does not deny that activities are social structures. With the subject identified as an individual person, the other participants in the activity are classified as members of the community. However, each member of the community does not necessarily share the same single objective of the activity as that held by the central actor. Rather, the community shares a “general object” (Engestrom, 1993, p. 67). Community members are each involved in connected activities directed towards related, but unique, objects, which together contribute towards the general objective. Kaptelinin (1996) referred to this as *polymotivation*: “it is not necessary that all component subjects share the motive of the system they are incorporated into, but the goals of the subjects should permit polymotivation, that is, should satisfy motives of both the component subject and the system” (p. 58).

An example to illustrate this can be taken from an activity in which I am currently engaged: the activity of doing a PhD. I am the individual at the centre of this activity, and the object that motivates the activity – my PhD thesis – distinguishes it from other similar activities (such as the PhD activity that my fellow students are undertaking). The community involved in this activity includes my supervisors, other staff members in the department and university, fellow students, friends and family, and the people who have participated in my research. Each of these community members is involved in various other activities, some of which are

essential to my PhD activity. For instance, my supervisors are involved in the *supervision activity*, which has a similar, but distinct, objective. However, without this related activity I would not be able to achieve my objective. Thus, activity systems are not stand-alone. They are *societal* (Tolman, 1999) in the sense that each activity system is part of “an interconnected web of activities” (Kuutti, 1991, p. 534). Conflicts between the objectives of these interconnected activities were described by Engestrom (1993) as contradictions, which give rise to the development of the activity. The concept of contradictions will be elaborated further below, in Section 3.3.4.

Meanwhile, in order to fully understand and utilise the activity system model as an analytical framework it is necessary to define each component in the activity system. The **rules or regulations** were defined by Engestrom (1993) as “the explicit and implicit regulations, norms and conventions that constrain actions and interactions within the activity system” (p. 67). Thus, they can consist of both formal laws and procedures as well as more informal and implicit ways of doing things. To return to the example of the PhD activity, formal rules in this activity system might include the regulations set out by the university regarding the conduct of postgraduate students and supervisors, the maximum time allowed to complete the thesis, and the formatting guidelines for the thesis itself. Informal and implicit regulations might include my own preferred working practices – such as constructing the thesis while sitting at a computer desk as opposed to working in a library – and the accepted practices for communicating with members of the community – such as emailing supervisors and telephoning research participants.

Rules share many similarities with the concept of tools and it may sometimes be a matter of interpretation as to whether a particular artefact is classified as a tool or a rule. For example, one of the people I interviewed for Case Study C described his role as a duty manager in the organisation where he worked. This role was shared between ten senior members of staff, who would each take on the role for a week at a time. The person acting as duty manager was responsible for dealing with any operational incidents that occurred within the gas and oil exploration activities of the organisation. Each duty manager would carry a handbook detailing the procedures to follow when an operational incident occurred. The handbook identified the names and telephone numbers of the appropriate people to contact and other resources the duty manager might need. This artefact, then, served as both a mediating tool in the activity and a representation of the rules governing the actions the duty manager must take when an incident occurs. Thus, the rules or regulations within an activity may also sometimes be perceived as mediating artefacts. Indeed, rules are also mediators – they mediate the relationship between the subject and community (Kuutti, 1996). So in the case of the duty management activity, the rules presented in the handbook determined which members of the community the duty manager should contact, and how they should be contacted, when an operational incident occurred.

The **division of labour** in an activity system refers to “both the horizontal division of tasks between the members of the community and to the vertical division of power and status” (Engestrom, 1993, p.67). It is through the *horizontal division of tasks* that actions are divided among members of the community. So to return to the PhD example, the action of reading and reviewing a chapter of the thesis would be assigned to a supervisor (this action also forms part of the supervision activity),

while I would undertake the actions of writing and redrafting the chapter. The division of labour, therefore, serves as a mediator between the community and the objective of the activity (Kuutti, 1996). It is through the division of labour that members of the community are able to work together to achieve the general objective of that particular activity.

As with the other components of the activity system, however, the precise definition of the division of labour in a particular activity system is open to interpretation. For instance, some aspects of a division of labour may also be described as the rules of an organisation. In the PhD example, the organisational rules governing this activity assign particular roles to supervisors and students. Thus, the division of labour between supervisors and students is partially determined by the rules of the activity. It is apparent, therefore, that there is much interconnection between the components of an activity system. Consequently, when one component of an activity system changes and evolves – for instance, a new tool is introduced or organisational regulations are updated – this will have a modifying effect on the other components in the activity system. Thus, all activity systems are in a constant state of development and transformation (Engestrom, 1993).

In this section I have outlined the activity system framework that describes the sociocultural context in which activities take place. However, this framework does not explain the processes through which activities are carried out. The activity system framework divides activities *horizontally* into the elements that constitute the social setting in which activities take place (Halloran, 2000). In the following section, I will describe the *vertical* division of activities into actions and operations.

3.3.3. The three levels of activity

Activities consist of specific goal-directed *actions*, which in turn constitute *operations*, the routine, automatic processes that enable the goal of the action to be reached. The division of activity into these hierarchical layers is attributed to Leont'ev (1978). He argued that each level in the activity corresponds to the motive, goals, or conditions of the activity, as shown in Figure 3-3. The vertical arrows in this figure signify the fluidity between these hierarchical layers, which will be discussed further in Section 3.3.4.

In this hierarchy, the highest level is the **activity** itself (that is, the activity system), which is distinguishable by its **motive** (or objective). The second level consists of the **actions** that make up the activity. These might also be called tasks. They are the actions that individual members in an activity system undertake in order to achieve specific goals that contribute to the overall motive of the activity. Thus, actions are distinguishable by their **goals**. Like activities, actions are tool-mediated: they are achieved through the use of available tools. The available tools represent the **conditions** of the activity and it is the conditions of the activity that determine the **operations**, or routine processes, that are used. Operations are not typically available in conscious awareness (Nardi, 1996b). That is, when carrying out operations people do not normally have to think about those operations. When they do have to think about an operation, however, it ceases to become an operation, and instead moves to the level of an action.

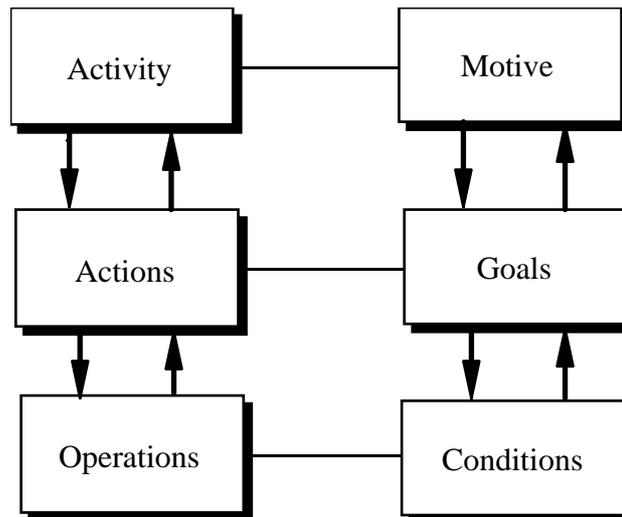


Figure 3-3. Activity, actions, operations (adapted from Kuutti, 1996)

The distinction between activities, actions and operations can be illustrated by the example of the reading activity that is the focus of Case Study A in this thesis (described further in Chapters 5 and 6; see Figure 3-4). This activity involves reading course texts in a distance education course. The course texts represent the object of the activity. The motive of the activity is learning, which in this case means developing a sufficient understanding of the course texts to assimilate this information with the rest of the knowledge and experience gained from participation in the course. Some of the actions contributing to this activity might include reading specific documents, taking notes, annotating the text, discussing the course materials with other students, and so on. The operations through which these actions are performed would include turning pages in the document, using a pen and paper to take notes, and flicking through the document to move back and forth between sections. These operations are dependent on the conditions of the activity. For example, if a student was reading a document on the PDA rather than on paper, then the operation of “flicking through the document” would no longer apply. Instead, the operation might be to scroll through the screen displays of the text.

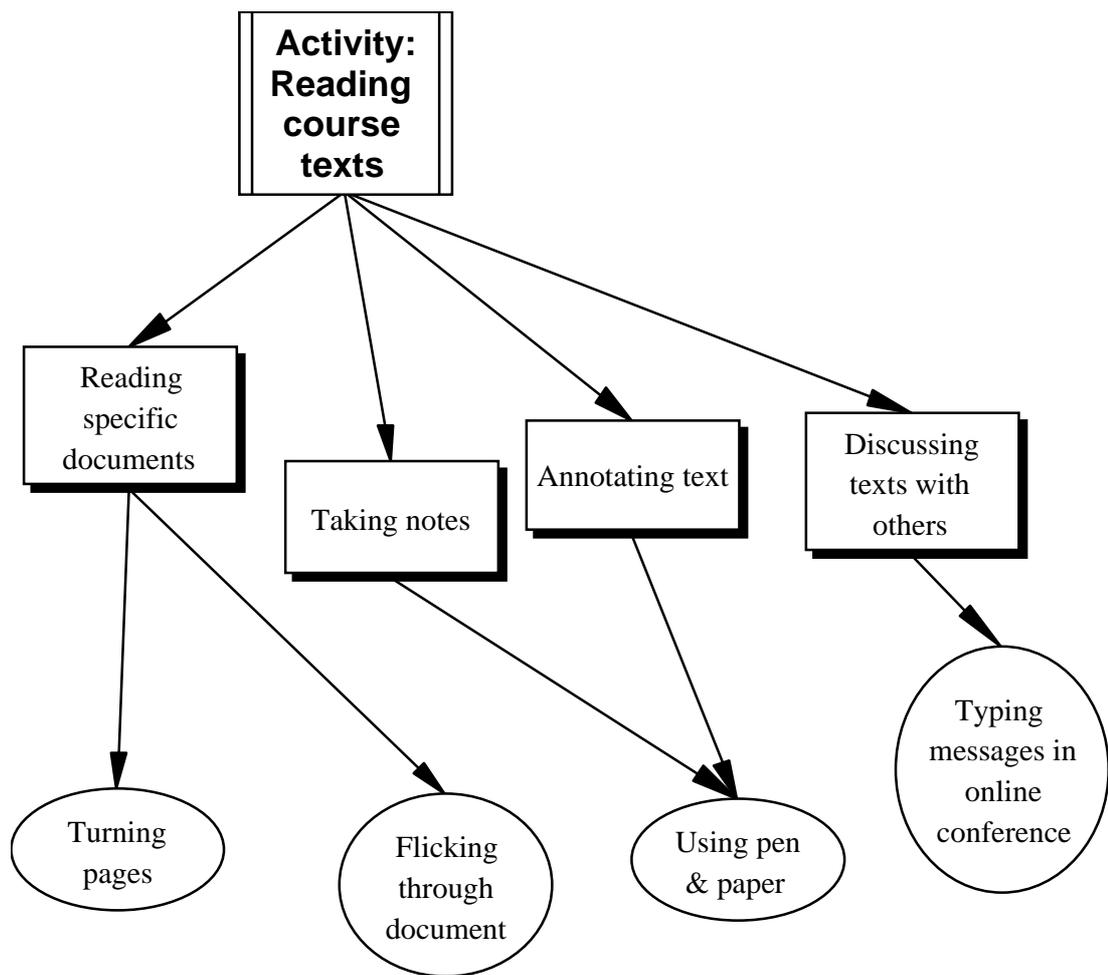


Figure 3-4. Example of actions and operations in reading activity

Given the different conditions each student would be working under, it is likely that they would each utilise a different set of operations when carrying out their actions. Similarly, the actions performed would vary across students. That is, the objective of an activity can be realised through different sets of actions (Leont'ev, 1978).

Likewise, the same action might contribute to different activities. For example, reading a specific document can contribute to the reading activity described here, but it can also contribute to the activity of preparing a course assignment. This is one of the reasons that an action cannot be understood without reference to the activity to

which it belongs. Actions that appear the same but contribute to different activities would have different meanings for the people undertaking them (Kuutti, 1996). Kuutti gave an example of “the action of reporting on the progress of a project” which he said would “have a different connotation if it belongs to the activity of internal project management than if it belongs to the activity of competing for promotion – even if the action and its other ingredients are exactly the same” (p. 31). Thus, while research carried out within the framework of activity theory might focus on individual actions, such analysis would be meaningless without reference to the overarching activity to which the action belongs:

it may be very fruitful to move from the analysis of individual actions to the analysis of their broader activity context and back again. Actions are not fully predictable, rational, and machine-like. The most well-planned and streamlined actions involve failures, disruptions, and unexpected innovations. These are very difficult to explain if one stays at the level of actions. The analysis of the activity system may illuminate the underlying contradictions that give rise to those failures and innovations. (Engestrom, 1999, p. 32)

In the case studies presented in this thesis, analyses have been conducted both at the level of actions and at the level of activities. Participants were most articulate about the actions they undertook, rather than their broader activity systems. This is consistent with Wertsch’s (1985) contention that people are unlikely to be aware of, or able to consciously reflect, the activity systems in which they operate. Thus, within each case study much useful information arose from descriptions participants gave of their actions and how the PDA was used to mediate those actions. However, the activity system concept was useful for highlighting aspects of the context in which the PDA was used, providing a way of looking at how sociocultural factors influenced the way the PDA was appropriated. In fact, tool appropriation was analysed as an activity system in itself, which will be described in Chapter 5. Tool

mediation, meanwhile, was primarily analysed at the level of actions with reference to the activities to which those actions belonged. This analysis incorporated the concepts of *breakdowns* in the actions and operations that make up the activity, and *contradictions* in the activity system. These are described below.

3.3.4. Activity system development

As outlined at the beginning of Section 3.3, one of the central ideas in activity theory is the notion that all activities are in a constant state of development and transformation. At the level of the activity system, this development is said to be driven by the introduction and resolution of contradictions within the activity system. Meanwhile, as activities evolve, the relationship between the actions and operations that make up the activity also change. The following section describes how these changes occur.

Actions, operations, and breakdowns

Like all elements of an activity system, actions and operations are not static but are under constant development. For instance, some actions may, over time, become routine processes that no longer require conscious awareness. Thus, they become *operationalised* – that is, transformed into an operation. In this case, the new operation would be used to execute other goal-directed actions. The often cited example that Leont'ev (1979) gave was that of learning to drive a car:

Initially, every operation – for example, shifting gears – appears as an action subordinated to a goal . . . Subsequently, this action is included in another complex action, such as that of changing the speed of the automobile. At this point, shifting gears becomes one of the methods for carrying out this action – that is, it becomes an operation necessary for performing the action. It is no longer carried out as a special goal-directed process. (Leont'ev, 1979, p. 64)

Conversely, operations can become actions when the conditions of an activity change. For instance, in the example given above the operationalised process of changing gears might be raised to the level of conscious awareness again – that is, become an action – when a new car is used. As the driver becomes familiar with the gear-box on the new car, the action of changing gears would again be operationalised.

Bodker (1991) gave the example of using a new word processor when writing a letter. In this instance, the operations that had been built up through the use of more familiar tools would no longer apply, and the user would need to execute each process involved in writing the letter as a specific goal-directed action. This can be likened to any instance when a new computer program is used to support a work activity. Initially the “repertoire of operations” at the user’s disposal cannot be applied to the new tool (Bodker, 1991, p. 27). However, as the new tool becomes familiar to the user, he may develop a new set of operations that relate specifically to the use of that tool. As more operations relating to that tool develop, use of the tool becomes easier and less prone to breakdowns.

Bodker (1991) defined breakdowns as “situations in which some unarticulated conflict occurs between the assumed conditions for the operations on the one hand, and the actual conditions on the other” (p. 27). That is, breakdowns occur when there is conflict between the operations at the user’s disposal and the operations required from the specific conditions of the activity. Breakdowns can often be instigated by the use of new tools. As described above, the user’s established repertoire of operations may be quite different from the operations required to use the

new tool. Furthermore, breakdowns occur when the tool no longer works the way the user expects it to – for instance, when there are mechanical breakdowns:

Material conditions other than the computer application can cause the breakdown, and even when we talk about the computer application such things as software and hardware errors can cause breakdowns. In the worst case, a user will see the word processor as some boxes and moving parts.

(Bodker, 1991, p. 38)

That is, when breakdowns occur the tool may no longer be perceived as a tool; and instead be considered a set of isolated parts. When breakdowns occur, operations that would normally be carried out automatically – without conscious awareness – become *conceptualised*. That is, they move to the level of actions where they are carried out as specific goal-directed processes. Thus, by causing breakdowns a new tool can have a substantial impact upon the development and transformation of actions and operations. This is one example of the way an activity can evolve over time. It will be given much attention in the analysis of the case studies in later chapters of this thesis. Meanwhile, the concept of contradictions helps to explain how activity systems evolve, as described below.

Contradictions

Contradictions occur within and between activities, and it is through the introduction and resolution of contradictions that activity systems evolve. Contradictions “manifest themselves as problems, ruptures, breakdowns, clashes” (Kuutti, 1996, p. 34). There are always contradictions in an activity system, and they are necessary, although disruptive, for the development of the activity.

Engestrom (1987) identified four types of contradictions, as shown in Table 3-1. A *primary contradiction* is a “fundamental tension” in an activity system that manifests itself within each component of that system (Engestrom, 1993, p. 72). Engestrom cited the example of a medical activity system, which is the focus of much of his developmental work research. In this activity, the object is the patient(s) visiting the doctor. The object represents two opposing motives: on the one hand, the doctor must see as many patients as possible in order to maintain a cost-efficient service, while on the other hand she has a duty of care to the patient which means she should spend as much time with the patient as necessary to adequately diagnose and prescribe treatment. Thus, “physicians typically experience a constant latent tension between their role as gatekeepers and cost-efficient producers on the one hand, and as healers or consultants on the other hand” (Engestrom, 1993, p. 72).

Table 3-1. Four types of activity system contradictions

Primary Contradictions:	These are inner conflicts represented within each node of the activity triangle.
Secondary Contradictions:	These occur between nodes (or components) of the activity triangle. For example, there may be conflict between the tools used in the activity and the rules that govern the activity.
Tertiary Contradictions:	Contradictions between existing activities and more advanced forms of those activities as they undergo transformation.
Quaternary Contradictions:	Contradictions between co-existing activities.

Secondary contradictions occur between two or more components in an activity system. According to Engestrom (1993), secondary contradictions “are the moving force behind disturbances and innovations, and eventually behind the change and development of the system” (p. 72). The concept of secondary contradictions can be illustrated by a well-known study which examined the introduction of *Lotus Notes* as

a knowledge-sharing tool in a large management consulting organisation (Orlikowski, 1992; Orlikowski & Gash, 1994). Although the authors did not use activity theory, there were clearly contradictions within the workplace they studied, which may have explained why the new tool was not successfully integrated into the users' activity systems.

Orlikowski and Gash (1994) suggested that the lack of success of Lotus Notes in this organisation was due to a difference in what they called the *technological frames* held by the technologists and management consultants. Drawing on cognitive science constructs, such as schemas and mental models, as well as sociocultural theories, they defined technological frames as the beliefs people hold about how a particular technology should be used. This is similar to Cole's (1996) notion of the conceptual meaning of an artefact. The problem encountered by Orlikowski and Gash was that the technologists in the organisation (who were responsible for implementing the new tool) saw Lotus Notes as a powerful and useful knowledge-sharing tool that encouraged collaborative working, while the management consultants saw the new tool as a burden. They did not have time to learn to use the new tool and, more crucially, did not want to use a knowledge-sharing tool because they were concerned that other people might take credit for their work. This was due to one of the rules of the organisation: that promotion for management consultants was competitive and based on individual merit. Thus, there was a secondary contradiction between the collaborative working tool and the competitive promotional structure (rule) of the organisation.

Tertiary contradictions represent a conflict between two forms of an activity – the existing activity and its *culturally more advanced form* (Engestrom, 1987). This type of contradiction, then, involves some upheaval during the evolution of an activity system. This can be illustrated by extending, and speculating upon, the Lotus Notes example above. It may have been that the introduction of Lotus Notes in this setting was part of a wider drive within the organisation to improve knowledge-sharing practices among workers. Existing staff, however, had been encultured into an organisation that encouraged, and rewarded, an individualistic style of work. Amidst the process of change within the organisation, there would have been a tertiary contradiction between the original form of the activity (where individual work was the norm) and the culturally more advanced form (where collaborative work practices were encouraged). This would have caused considerable tension within the organisation.

Finally, a *quaternary contradiction* exists between two different but interconnected activities. For example, co-existing activities may have conflicting objectives or rules and divisions of labour. Such conflict may become manifested in a breakdown in one or more of the different activities. The concept of quaternary contradictions can again be illustrated by a study examining the introduction of Lotus Notes, this time in an educational setting. Halloran, Rogers and Scaife (2002) used activity theory to examine the use of Lotus Notes as a collaborative learning tool by computer science students working on a group project. Like Orlikowski, Halloran et al found that students did not use the new tool in the way tutors (responsible for implementing the tool) had anticipated. One of the reasons for this was that there was an underlying contradiction between what tutors and students believed was the

objective of the group learning activity. Students were focused on successfully creating the product of their joint project, a fully operable computer game. In contrast, the tutors' primary concern was to support and teach group working skills. Thus, tutors believed that Lotus Notes, which provided a space for sharing documents and creating meeting notes that could be viewed by tutors, would be a valuable tool in this activity. However, students found that using the tool distracted them from their target of achieving a successful outcome, despite the fact that their group working processes, as recorded in Lotus Notes, were assessable. Thus, there was a quaternary contradiction between the activity systems of the students and the tutors, and this had an effect on the way the new tool was (or rather, was not) used.⁸

The concepts of contradictions and breakdowns are closely related. Contradictions can lead to breakdowns; in fact, contradictions may manifest themselves as breakdowns (Kuutti, 1996). Therefore, research that seeks to uncover the existence of contradictions within an activity system might involve the observation of breakdowns. That is, observing incidents of breakdowns within the actions and operations that make up an activity may indicate underlying contradictions within an activity system. Therefore, research directed at understanding the impact of new technologies on activities should involve the analysis of both contradictions and breakdowns.

⁸ However, Halloran et al did not view the conflict in this way. They did not describe the tutors' and students' activities as separate, coexisting activities; instead they attempted to model the two activities as part of the one activity system, leading to the development of the rather complex Activity Space framework (see also Halloran, 2000).

Examining contradictions enables the identification and classification of particular instances of change and development in an activity system. Analyses directed towards the identification of contradictions in an activity could enhance HCI and other technology evaluation research in two ways. Firstly, by specifying the contradictions apparent in an activity system, researchers could identify possibilities for new tools that may help overcome those contradictions. For example, Turner and Turner (2001) examined contradictions within the activity of student enrolment in a university in order to identify requirements for the development of new technical tools to support this activity. Thus, understanding contradictions could help inform systems design.

Secondly, the introduction of a new tool would also modify the activity system, thus creating new contradictions between the different components in the system. Engestrom (1993, p. 72) argued that when a “novel” element is “injected” into an activity system it creates new contradictions which lead to further development of the activity system. Thus, research examining the impact of a new technology in a particular learning or workplace setting should include consideration of the contradictions in the activity system – both those contradictions that the new tool helps to resolve and the contradictions created by its use. Such contradictions could highlight other problematic aspects of the activity system that require intervention in order for the activity to continue to operate effectively and achieve its objectives.

The concept of contradictions will be referred to throughout this thesis. The analysis of Case Studies A and B sought to identify the contradictions that the PDA created (Chapter 6). Meanwhile, in Case Study C, the analysis included consideration of the

existing contradictions in the activities that may have had an effect on the way the PDA was used or revealed potential new uses for the PDA (Chapter 7). The analysis of contradictions was conducted alongside an analysis of the changing relationship between actions and operations that made up the activity, thus enabling a rich description of the mediating effect the PDA had upon learning and workplace activities. In the following section, I will describe in more detail how activity theory concepts can be used to inform an understanding of tool appropriation and tool mediation. In particular, I will describe how tool appropriation can be analysed as an activity system in itself, and how new tools can have a dramatic effect on the activities they are used to support.

3.4. AN ANALYTICAL FRAMEWORK: ACTIVITY THEORY, TOOL APPROPRIATION, AND TOOL MEDIATION

In the previous section, I introduced the main concepts from activity theory that have informed my research. In the following discussion, I return to the two themes that were introduced at the beginning of this chapter: tool appropriation and tool mediation. The intention is to link these themes with the activity theory concepts outlined above. This will provide some context to the analysis of the case studies that will be described in later chapters, demonstrating how I have employed activity theory concepts in this analysis.

3.4.1. Tool appropriation as an activity system

The relevance of activity theory to studies of technology use can be clearly seen in the concept of tool mediation, as described in Section 3.2. According to this view, computer systems can be analysed as mediating tools in human activity. However, it

is not so obvious how activity theory can be applied to the concept of tool appropriation. This problem was hinted at by Kuutti (1991):

IS development is easily described as an activity, but what about IS use? Is that an activity too, or where do information systems fit into activities? ... A natural first answer would be to position IS as a tool for some activity ... IS can certainly serve as a tool, but that definition alone is too restrictive. (p. 537)

That is, Kuutti suggested that examining the use of computer tools (which he referred to here as information systems) involves more than just looking at the computer's role as a mediating artefact in human activity – perhaps “IS use” could also be described as an activity. Kuutti did not clarify what he meant by “IS use,” but it could be assumed that he was referring to a process of tool appropriation. Following his suggestion, then, it might be fruitful to consider tool appropriation as an activity: the tool being appropriated would be the object of this activity. This relates to the more general idea that artefacts have dual status as both objects and tools:

Artifacts are there for us when we are introduced to a certain activity, but they are also a product of our activity and as such are constantly changed through the activity. Artifacts thus have a double character: they are objects in the world around us that we can reflect on, and they mediate our interaction with the world, in which case they are not themselves objects of our activity in use. (Bodker, 1996, p. 149)

Taking the ideas put forward by Kuutti and Bodker, I have developed the *Activity System Tool Appropriation Model* (ASTAM), shown in Figure 3-5, which represents tool appropriation as an activity system. The intended outcome of the activity is to integrate the new tool into other existing activities. As discussed earlier (in Section 3.1.1), tool appropriation is defined in this thesis as the integration of a new tool into

the user's activities. Thus, the new tool is both the object of this activity and a mediating tool in other activities.

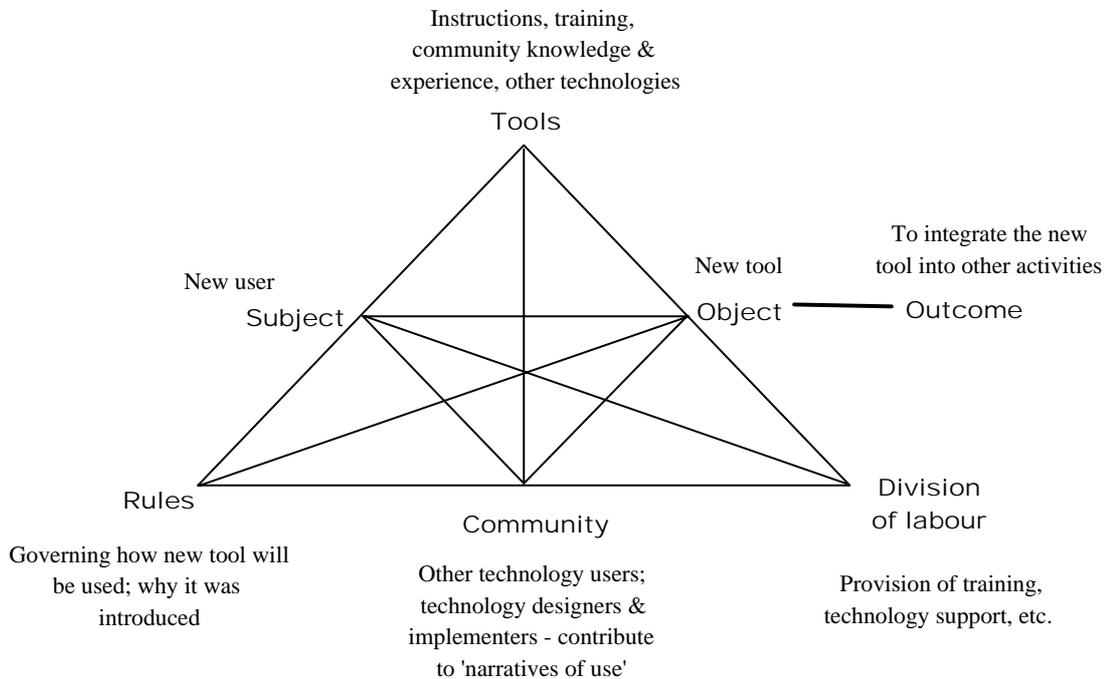


Figure 3-5. Tool appropriation as an activity system: The *Activity System Tool Appropriation Model (ASTAM)*

The ASTAM framework shows that the tool appropriation activity takes place within a community of other people. This could include colleagues or friends who might also be learning to use the new tool, technology designers, and those responsible for implementing the new tool in that particular context. Members of the community would contribute to the “narratives of use” that may shape how the user perceives the tool. Churchill and Wakeford (2002) defined narratives of use as general discourses relating to how technologies (in particular, mobile technologies) can and should be used. They argued that narratives of use are gleaned from media representations – such as advertisements and newspaper reports – as well as from “personal experiences and the experiences of others one knows or can observe” (p. 164; this

concept was also discussed in Chapter 2). Thus, community members could be an influential source of discourse about how the technology should be used.

In addition, there will be rules and a division of labour mediating how the new tool is introduced and used. For instance, in the study by Halloran et al (2002), the introduction of Lotus Notes was driven by rules regarding the assessment of student group working processes. Similarly, in Orlikowski's (1992) study there was a clear division of labour governing the introduction of Lotus Notes: the technologists were responsible for implementing the new tool while the management consultants had to make time to learn to use it.

As in any activity system, there will also be tools that mediate the activity. In the tool appropriation activity these might include instruction manuals that specify how to use the device, training programs, community knowledge, and other technologies with which the new tool must be integrated. Furthermore, the user's past experience and existing knowledge might also mediate how the new tool is used. Shelton, Turns and Wagner (2002) related an incident that illustrates the importance of past experience. They conducted an observation and interview study of the use of a new web site by volunteers working at an Arthritis Helpline. They observed one volunteer whose past experience consisted of positive encounters with generic Internet search engines. When asked to find information on the new arthritis web site, then, she immediately chose to use its internal search engine. After spending several minutes following up unsuccessful leads, she was eventually able to locate the information. In contrast, another volunteer whose past experience with

computers and the Internet was more extensive, found the information by navigating through the menu system, a procedure that was successful within seconds.

The ASTAM framework differs from the models developed by DeSanctis and Poole (1994) and Carroll and colleagues (Carroll, Howard, Peck et al., 2002; Carroll, Howard, Vetere et al., 2002), which were discussed in Section 3.1.3. Unlike Carroll's model, the ASTAM framework does not set out to describe tool appropriation as a series of stages. Rather, it treats tool appropriation as an ongoing and continually evolving process, as all activity systems are (Engestrom, 1993). Furthermore, by using activity system concepts, ASTAM helps to develop an understanding of the interrelated sociocultural factors that contribute to the process of tool appropriation. However, unlike the "adaptive structuration theory" model developed by DeSanctis and Poole, these sociocultural factors are not seen to be *a priori* structures; instead, they are inherent elements of the activity system. Furthermore, the ASTAM framework can be used to describe tool appropriation in any context, not just in the workplace (which is what DeSanctis and Poole aimed to do), and it allows for a rich description of the various elements at play when an individual appropriates a new tool. In contrast, DeSanctis and Poole used the generic terms "organisational structures" and "workgroup structures" as all-encompassing labels to describe rules, regulations, divisions of labour, and any other "structures" that they deemed relevant. The activity system framework gives greater definition to these elements.

The ASTAM model allows for an analysis of tool appropriation as an *individual activity that is socially situated*. This again differs from the model by DeSanctis and

Poole in that their theory focused on the appropriation of new technologies by work groups and underplayed the importance of the individual user. In an analysis based on the ASTAM framework, the user, and the user's motivation for using the new tool, as well as his or her objectives in other related activities, remain central to the analysis. However, the ASTAM framework also emphasises the importance of the context in which the activity takes place, and in this sense it further differs from Carroll's model of technology appropriation (Carroll, Howard, Peck et al., 2002; Carroll, Howard, Vetere et al., 2002).

There are, of course, limitations in the ASTAM framework, which are mostly related to the general limitations of the activity system approach. For instance, each of the components within the activity system framework is open to interpretation. This means there are no clear guidelines governing how the different labels in the ASTAM framework should be used. This could be particularly problematic if the framework were to be adopted as a tool for researchers unfamiliar with activity theory concepts. For instance, one conceivable use of the ASTAM framework is that it might be adopted by systems designers and educational technology evaluators as a way of better understanding the tool appropriation process, leading to better-informed decisions about technology design and implementation. However, without the background knowledge of the activity system model upon which the ASTAM is based, the framework may not be accessible for systems designers and technology evaluators. These limitations will be discussed further in Chapter 10.

Nevertheless, the ASTAM framework presented in Figure 3-5 helpfully identifies multiple interacting elements that may contribute to the way a new tool is

appropriated in a given context. In later chapters, this model will be used as an analytical framework to examine the process of tool appropriation in Case Studies A, B and C (Chapters 5 and 7). The activity theory concepts represented in the ASTAM framework will be used to categorise and interpret the data describing how users came to appropriate the PDA in these studies. The ASTAM framework represents the first part of the two-way process of tool appropriation that was described in Section 3.1.4 (that is, how technology use is shaped by social factors). The second part of this process (how social factors are shaped by technology use) relates to the concept of tool mediation, which is revisited below.

3.4.2. How computer tools shape activities

Throughout this chapter I have emphasised the core component of activity theory: the notion that all activities are mediated by the use of tools. In Section 3.2, I stated that in this thesis tool mediation refers not only to how goals are achieved through the use of tools, but also to how new tools change activities. This relates to another central idea in activity theory: that all activities are in a constant state of transformation. In Section 3.3.4 I described how contradictions and breakdowns drive the development of activities. These concepts will be used in my analysis of how the PDA mediated learning and workplace activities in Case Studies A and B (Chapter 6). In order to illustrate why such an analysis of tool mediation is important, the following discussion describes two past studies that showed with particular clarity how new tools can have a dramatic impact on the activities they are used to support.

In the first study, which was reported by Hasu and Engestrom (2000), a new medical diagnostic tool – a *neuromagnetic measuring system* – was introduced in a hospital

setting. Hasu and Engestrom described an incident in which this tool was used for the first time in a hospital with a real patient. A doctor and nurse worked together, using the instrument to conduct a neurological measurement. The incident was characterised by contradictions and breakdowns. The existing division of labour between the doctor and nurse did not support the use of the new tool. Because new actions were required (for example, setting up the neuromagnetic measuring system and preparing the patient for the measurement), the two main actors in the activity had to negotiate the division of labour. The episode began with some confusion between the doctor and nurse as to whose role it was to prepare the measuring system. The nurse began preparing the patient for the measurement, assuming that the doctor would simultaneously prepare the tool. This action, however, was not completed by the doctor and so some delay occurred as the instrument was set up. This was in conflict with a rule of the activity, which specifies that “patients in poor physical condition have to be measured quickly, for safety considerations and to ensure the quality of the data” (p. 71).

These contradictions ultimately led to a breakdown in the activity. The neurological measurement failed: the doctor and nurse were unable to gain an accurate reading using the new tool. Hasu and Engestrom (2000) went on to describe other episodes relating to the development and use of this tool. However, this initial episode is of most interest here as it demonstrates how the new tool created novel actions, therefore requiring some negotiation of the division of labour in order for the actions to be performed in accordance with the rules of the activity. Given that these aspects of the activity system had not previously been established, there was some disruption to the activity and, ultimately, the objective of the activity was not realised.

In another workplace setting, Luff and Heath (1998) described the impact of notebook computers on the work activities of foremen working on a construction site. (They also described two other workplace settings but these will not be discussed here.) Luff and Heath took an ethnomethodological approach to this study. Ethnomethodology involves close observation of the minute details of activities, and includes consideration of the interactions between people and between people and objects (Suchman, 1987). Ethnomethodologists refute the use of theoretical frameworks to analyse their data (Macaulay, 2000). Thus, Luff and Heath did not use activity theory to interpret their study; I have taken the liberty of imposing activity theory concepts onto their findings.

I have done this because Luff and Heath's study clearly demonstrates how a new computer tool can change both the social activity system and the actions and operations which make up the activity. The study focused on a construction site foreman, whose job was to inspect gangs of manual workers distributed across the site. The notebook computer was originally used to replace a paper allocation sheet, a tool for recording various details about the tasks undertaken by gang workers. Using the notebook computer, however, disrupted the foreman's activity, modifying the informal rules related to his job and changing the way he worked with other employees on the construction site. For example, before the new tool was used, a general rule on the construction site was that the foreman was mobile, and gang workers expected to have contact with him at various points throughout the day as his movement crossed their paths. However, although the new tool was a portable

technology, it actually had the effect of reducing the foreman's mobility, as he tended to update the computerised records while in the site hut.

Furthermore, when he did use the computer while out on the construction site, it changed the way he interacted with other workers. The tool became a focus of the interaction: "the activity of filling in the allocation sheets became a focus of the work whilst out on site. What had been a brief handover of paper documents, and a transient interaction between ganger and foreman became an extensive activity" (p. 308). Thus, the new tool changed the activity by introducing a new action (filling in the computerised record) and eradicating a previously operationalised process (handing over the paper records). This had an impact on the division of labour of the activity, making it difficult for the foreman to interact with workers the way he had done previously, and also changed the informal rule relating to the foreman's mobility. Bodker (1996) referred to this type of disruption as a *focus shift*, involving a shift of focus from the objective of the activity to the tool itself. Such focus shifts are important to technology evaluation studies as they may represent underlying usability problems in the tool, thus identifying areas for potential improvement in the technology design.

The review of these two studies has demonstrated that it is important to understand how new tools mediate (and consequently change) activities when examining the introduction of new technologies in workplace settings. Of course, this is also an important issue when examining the use of new technologies in educational settings. In particular, this discussion has illustrated that new technologies can disrupt and change activities in sometimes undesirable ways. Therefore, it is important to

examine what Carroll et al (1991) referred to as the *possibilities* and *constraints* introduced by a new tool. In Chapter 6 of this thesis I will examine how the PDA mediated learning and workplace activities in Case Studies A and B. This analysis identifies both the possibilities and constraints that the PDA introduced to each activity, and links these to the activity theory concepts outlined above. In particular, the concepts of breakdowns and contradictions were useful in describing how the PDA had an impact on the activities it was used to support. From this analysis, I have developed a model illustrating the *Tool Integration Process* (TIP) – relating to the second part of the two-way process of tool appropriation, whereby social settings (activities) are shaped by technology use. This will be described further in Chapter 6.

3.5. CONCLUSION

The purpose of this chapter was to describe the theoretical background to this thesis. The chapter has discussed the two central themes of the thesis – tool appropriation and tool mediation – and clarified how activity theory concepts have informed this research. Activity is interpreted here as a constantly evolving system, embedded in a particular social setting. An activity system incorporates the actor participating in the activity, the tools used to mediate the activity, the object (motive) towards which the activity is directed, and the community, rules and division of labour, which also mediate the activity (Engestrom, 1987). Activities can also be divided vertically into sub-components, consisting of actions and operations. The basic unit of analysis in activity theory is the activity itself (Leont'ev, 1978). While actions can also form the focus of analysis, they can only be understood with reference to the activities to which they belong. Activities are constantly changing and evolving, both through

changes in the relationship between the actions and operations that make up the activity (Leont'ev, 1978; Bodker, 1991), and through the introduction and resolution of contradictions in the activity system (Engestrom, 1987, 1993). Thus, activity theory concepts are useful for describing how new tools change activities.

In this chapter, I have described tool appropriation as a two-way process. On the one hand, social factors influence the way new tools are used (or appropriated) in different social settings. Meanwhile, when a new tool is appropriated (that is, integrated into the user's activities), the tool changes those activities in numerous ways. That is, while users appropriate new tools, the new tools shape the users' activities. These two components are both important when examining the effect new tools can have on learning and workplace activities.

In the remainder of this thesis I will address the question of how PDAs are appropriated as learning and workplace tools, and how they mediate the activities they are used to support. As described in the previous section, concepts from activity theory will be used to inform this analysis. In Chapter 5, I will analyse tool appropriation as an activity system with reference to Case Studies A and B, using the ASTAM framework. This approach will also be used to describe the findings from Case Study C, reported in Chapter 7. Meanwhile, in Chapter 6, I will describe how the PDA mediated learning and workplace activities in the first two case studies. For this analysis, I will identify the possibilities and constraints the new tool introduced and link these to activity theory concepts to describe how the PDA changed the activities it was used to support. The following chapter, meanwhile, describes the

methods that were used in each of the four studies that were carried out for this research.

Chapter 4

Methodology & Methods

This chapter introduces the case studies that were conducted for this research. The procedures and methods used to collect and analyse the data are described below, following an overview of some of the methodological issues raised by the choice of activity theory as an analytical framework. The methodological implications of activity theory include, at the broadest level, a commitment to qualitative research strategies that allow for rich descriptions of the activity systems under investigation. Thus, this chapter begins with an overview of the qualitative approaches that have informed the design of this research. This will be followed by a description of the methods used to collect and analyse data in each study.

4.1. THE QUALITATIVE APPROACH

Activity theory, with its emphasis on understanding the context that gives meaning to individual actions and the role of artefacts in mediating activity, unsurprisingly advocates qualitative methods of inquiry (Tolman, 1999). Research informed by activity theory typically involves a range of qualitative strategies, including ethnographic studies (e.g., Macaulay, Benyon, & Crerar, 2000), video-recorded observations (e.g., Bodker, 1996), and interviews (e.g., Turner & Turner, 2001). One of the reasons these methods are suitable for an activity theory approach is that they do not aim to identify predictive variables. The problem, according to Tolman (1999), is that any attempt to identify and control predictive variables is based on the

positivist research tradition that is inconsistent with activity theory's more holistic view of the world. In a discussion of the methodological implications of activity theory, Tolman argued convincingly against what he called "Anglo-American empiricist methodology." He rejected the tradition in which social science is modelled on approaches found in the natural sciences, such as physics. Such approaches tend to be concerned with demonstrating statistical correlations between variables, so as to identify underlying laws. However, Tolman argued that such attempts just specify that there is a relationship but do not help to explain that relationship or detail the processes involved in the social phenomenon under investigation. If the purpose is to provide a detailed descriptive and explanatory account of the phenomenon, then demonstrating statistical relationships between variables is not an appropriate strategy. Instead, a more holistic and descriptive approach is required.

One such approach is ethnographic research, which has become accepted practice amongst HCI and CSCW researchers (Macaulay et al., 2000). However, within this literature there have been few attempts to define ethnography or specify what doing an ethnography actually entails (Harper, 2000). Ethnography is a term borrowed from the anthropological and sociological literature in which "doing ethnography" is similarly undefined (Macaulay et al, 2000). However, it is generally accepted that ethnographic research in those fields involves spending some time living or working in the culture or social setting that is under investigation, and then drawing on the observations and experiences had while in that setting to create a representation of the object of study (Hammersley & Atkinson, 1995).

In HCI, CSCW and educational technology research, ethnographic methods can include interviews with users or potential users of particular tools, analyses of documents and artefacts, observations of people interacting with the technology in their natural setting, as well as more general participant observation of the work setting (Macaulay et al., 2000; Nardi, 1997). According to Nardi, participant observation “involves spending a great deal of time with and participating in the everyday lives of the natives” (Nardi, 1997, p. 361). An example is the study by Macaulay et al (2000) in which Macaulay spent two days a week over a year observing the newsroom of a national newspaper (also reported in Macaulay, 2000). From this research she was able to develop a rich understanding of how information was used and shared in this work practice that contravened many assumptions held about information use and the work of journalists. Studies such as this can be useful for evaluating existing technologies as they are used in particular settings, and informing the design of new information systems. However, there are also varying interpretations about the importance of participant observation in ethnography. Some authors specify that a lengthy period of participant observation is a necessary feature of any ethnographic inquiry (e.g., Forsythe, 1999), while others believe that such a contention is “arrant nonsense” (Harper, 2000, p. 258). Thus, the form ethnography can take is widely open to interpretation.

The research presented in this thesis could not be labelled ethnography in the strictest sense of the term (e.g., Forsythe, 1999). The case studies did not involve an extended period of participant observation, although Case Study B was conducted in the department in which I am a student and as such I was able to carry out informal observations throughout the study. Nevertheless, all of the studies in this thesis do

incorporate some ethnographic methods such as semi-structured and open interviews and, to a lesser extent, observations. However, these could be just as easily included under the general rubric of qualitative research (Hammersley & Atkinson, 1995). What is important is that the approaches employed in this research are consistent with the purpose of the research and its theoretical foundations. As was established in Chapter 1, the main purpose of this thesis is to develop a rich description of tool appropriation and tool mediation in the context of the use of PDAs as learning and workplace tools. Therefore qualitative and ethnographic methods are appropriate. While it would have been beneficial to have been able to spend substantial amounts of time in one field setting, the chosen method of conducting four smaller studies enabled me to examine the use of PDAs across different settings, thus giving a broader view of tool appropriation and tool mediation than might otherwise have been possible.

Interviews with participants were the primary means through which data were collected in these studies. In this sense, the perspective of the user – which is sometimes lost in laboratory studies – became the central focus of the research. Nardi (1996b), a leading activity theorist, recommended the use of interviews in HCI research. She rejected the common belief that interviews are an unreliable source of data:

It has become a kind of received wisdom in the HCI community that people cannot articulate what they are doing (a notion sometimes used as a justification for observational studies and sometimes used to avoid talking to users at all). ... But this generalization does not apply to the higher conscious levels of actions and objects; ask a secretary what the current problems are with the boss, or an executive what his goals are for the next quarter, and you will get an earful! (Nardi, 1996b, pp. 81-82)

Interviews were used extensively in the case studies presented in this thesis and have provided rich data about how people used their PDAs, how they felt about them, and how these tools changed aspects of the user's activity systems. Even when conducted in isolation – without complementary observation studies (as in Case Study A) – the interviews provided information about the actions and operations people undertook. Although operations are usually captured through observation studies, Nardi suggested that they could also be articulated in interviews: “Skilful interviewing ... often bring(s) operations to the subject's conscious awareness so that even operations can be talked about, at least to some degree” (p. 82). Furthermore, as shall be revealed in the following chapters, I found that operations could be easily articulated when the new tool caused some disruption (or breakdown) in the activity. By talking about the disruption the PDA caused, interviewees were able to articulate both the operations and the actions that contributed to their activity.

In the following section, I will describe the methods used in the three main case studies that were carried out for this research, along with a description of the observation study in which I examined the use of PDAs at the Tate Modern art gallery.

4.2. THE STUDIES

4.2.1. Case Study A - PDAs in H802

In this study, postgraduate students on an Open University course were supplied with *Palm m105* PDAs, and given the opportunity to use the PDA to read some of the texts provided during the course. The purpose of this study, then, was to examine the effect the PDAs had upon the activity of reading in this context, as well as to

determine how useful the PDA was as a learning tool. The following describes the procedures that were used to undertake this study.

The H802 course

This study took place in 2001 and focused on a course called *H802: Applications of Information Technology in Open and Distance Education*. In many ways, this was not a typical Open University course. It was a postgraduate course, one of three that made up a masters program (MA) in open and distance education. Students could take the course on its own or as a contribution to the masters program. In addition, the course involved evaluating the use of computer technologies to support distance education. Therefore, students were encouraged to critique and evaluate their own experiences of using information technology while undertaking the course. For this reason, H802 offered a valuable forum in which to conduct this study. Students were generally eager to try out a new medium for reading course materials and offered extensive feedback on their experience of using the PDA for reading.

In 2001, the course was primarily delivered online, making use of web resources and FirstClass conferencing software. The final block of the course (the last two months), however, used printed reading materials, and it was during this block that the study was conducted, in August and September 2001. In addition to the PDA, students also had access to the printed versions of the course materials, which were supplied in an A4 ring-bound folder. Therefore, although all 65 students on the course were given a PDA, use of the PDA to read course materials, and participation in the study, was voluntary.

Pre-questionnaire

Before the PDAs were sent out to students (in July 2001), an online questionnaire was administered (see Appendix A). Forty-four responses were received. The purpose of this questionnaire was to gain some understanding of students' existing reading strategies, and to ascertain students' preconceptions about the PDA and their expectations of how useful it would be in the context of their studies. Questions asked students to rate how useful they believed the PDA would be, and to describe what they thought would be the benefits and limitations of the PDA. Students were also asked whether they already owned or used a PDA. Of the 44 people who responded to the questionnaire, eight said they had used a PDA before. Therefore, most of the participants in this study were novice PDA users, although many of the students who took part in the follow-up interviews had their own PDAs (see below).

PDAs

All students were supplied with a Palm m105 PDA. This PDA was chosen because it was a relatively affordable model that offered all of the features common to PDAs, such as note-taking facilities, an address book, calendar and to-do list, as well as options for additional features such as email and Internet access. The m105 had 8mb of Random Access Memory, which was sufficient for storing a large amount of electronic text. Palm PDAs were widely available and a variety of third-party software could be used with this platform, enabling students to explore the potential uses of PDAs beyond reading course materials.

The Palm m105 had a touch-sensitive screen, and screen icons were manipulated by using a pen stylus or finger to tap on the screen. Text could be entered by tapping letters on an onscreen keyboard, or by using the Graffiti handwriting recognition

software. This involved learning the specific Graffiti alphabet characters and writing these on the screen with the stylus. The computer would then convert the handwriting to type.

WordSmith and course texts

Along with the PDA, students were supplied with a CD-ROM that contained software for *WordSmith*, a commercially available document editor and viewer, which was used to present course materials on the PDA. This was chosen because it was a flexible program that could be used for a variety of purposes, including recording notes, editing documents, and reading text. Three sections of the Block 4 course materials (67 pages) were provided in Microsoft Word document format on a CD-ROM, which could then be downloaded onto the PDA and viewed through *WordSmith*. The documents were not reformatted for presentation on the PDA. They were entirely text-based, as images could not be viewed on the *WordSmith* software. These documents constituted nearly half of the *Study Guide* for the final block of the course, a collection of discursive texts written by academics associated with the course.

FirstClass conference

Students also participated in a computer-mediated discussion conference. Discussion conferences were a core element of the course, and therefore students were familiar with using the *FirstClass* conferencing software and sharing information and experiences with other students through the conference. Two discussion forums were established for the purposes of this study. The first was set up before the PDAs were sent out to students, and was an opportunity for those who already used PDAs to talk about how they used the device and what they thought about the intention to

provide course materials on a PDA. Some novice users also participated in this discussion to express their interest in the study and further their knowledge of how PDAs could be used.

The second forum was established once students had received the Palm m105 PDAs. In this forum, students shared their experiences of using the PDAs to read course materials, offered each other advice about software and features to try, and helped each other with any technical difficulties they experienced. This forum therefore provided a useful means of capturing data about how some students used the PDAs. Twenty-seven students contributed to this discussion. Of those, six students were particularly active in the conference and were responsible for 47% of the messages between them. The discussions were not mediated or directed by tutors or evaluators. Researchers participated in the conference only to answer specific queries or to make announcements about the study.

Post-questionnaires

Following the final block of the course, online post-questionnaires were administered, consisting of both open and closed questions (see Appendix B). Items asked students what features of the PDA they had used, whether they had found the PDA to be a useful tool for supporting their studies, what sort of reading strategies they adopted when using the PDA (e.g., highlighting, taking notes, underlining), and what the benefits and limitations were of using the PDA to read course materials. Thirty-five students returned the post-questionnaire.

Initial interviews

Semi-structured interviews were conducted by telephone with 10 randomly-selected students (four male, six female). The interviews were designed to elicit in-depth information about students' use of the PDAs, to find out how the use of the PDA changed students' reading strategies, as well as to gain further understanding about the issues that impacted upon students' use of the PDAs. A pilot interview was initially carried out, and questions were revised following this and other early interviews (see Appendix C).

Follow-up interviews

Several months after the course had ended, students were contacted again to find out if they were still using the PDA (they had been allowed to keep the device), and if so, how they were using it. Several students responded to this email and, following further contact, eight students agreed to take part in a follow-up telephone interview (two male, six female). Of those, two had also been interviewed during the initial stage of the research. Most of the follow-up interviewees were enthusiastic PDA users who either used the Palm m105 supplied for the study or had their own similar device. Only one non-user volunteered to be interviewed at this stage. The intention had initially been to talk to a range of PDA-users and non-users in order to gain some understanding of the factors contributing to the variation in the way students adopted the PDA. However, I was relying on voluntary participation in this study, and the people who wanted to take part were mostly PDA users. Nevertheless, the resulting interviews were valuable in providing information about how the device had been appropriated in different ways by different users. Appendix D shows a list of questions used as a guide in these interviews.

4.2.2. Case Study B - PDAs in IET

In this study, 11 staff members (five male, six female) from the Institute of Educational Technology (IET) at the Open University used PDAs as general workplace tools. Participants volunteered to take part in this study. The purpose of the study was to explore how the PDA could be used in this context and to examine the impact it had on general workplace activities. The study took place over a two-year period, although most of the data were collected during the first six months of the study (July - December, 2001).

The workplace setting

IET is an academic department whose work includes researching the use of technology in education, and providing advice about the development of the Open University's distance education course materials. All participants in this study were either academic or academic-related staff. They were employed as lecturers, directors of research projects or teams, and project officers. Their jobs involved undertaking research and publishing the results of that research – either in internal reports, in academic journals or at conferences – as well as teaching and preparing learning materials for Open University courses. Some academic staff members also had managerial responsibilities as directors of particular projects or research groups.

Given the focus in IET on the use of technology in education, participants in this study were likely to keep abreast of new technologies. They were motivated to take part in this study because they wanted to explore the ways in which PDAs could provide support for their work and learning activities. They expressed enthusiasm about testing out different features and functions of the device and were keen to explore the different activities for which PDAs could be used. Therefore, they may

be considered atypical technology users, as they had a professional interest in finding out about, and learning to use, new technologies. Nevertheless, this was not a homogenous group. Participants varied greatly in the extent to which they adopted and used the PDA, and differed in the way they integrated the device into their workplace activities. Furthermore, as in Case Study A, participants' interest in new technologies may have been beneficial to this study. They were able to provide in-depth reflections about how they had used the PDA, thereby providing a rich set of data based primarily on self-report methods.

PDA's

Participants were given one of three PDA's, which were chosen following consultation with participants to find out which features and functions of PDA's would be particularly useful to them (the results of this consultation are reported in Chapter 5). The chosen devices were:

- *Palm Vx*. This PDA used a Palm operating system and had features such as a calendar, memo-pad, email storage, and an address book database. It had a rechargeable battery and was supplied with a cradle that connected to the desktop computer, allowing for synchronisation between the two machines. The battery could be charged when the PDA was connected to the cradle. The Palm Vx had a monochrome black and green display and a touch-sensitive screen. Three participants used this PDA.
- *Handspring Visor Deluxe*. This also ran on a Palm operating system and offered the same features as the Palm Vx. The Handspring, however, had disposable batteries. It was also supplied with a cable that connected to the desktop computer and had a monochrome black and green display with a touch-sensitive screen. Five participants used this PDA.
- *Hewlett Packard Jornada*. This PDA used the Windows Pocket PC operating system and featured Microsoft applications that are typically also found on

Windows-based desktop computers (e.g., a word processor, spreadsheet, email, and web browser). The device had software for reading e-books, a media player, and a facility for recording voice memos. It had a rechargeable battery and also could be connected to the desktop computer, allowing data to be synchronised between the two machines. The Jornada had a full colour display and a touch-sensitive screen. Three participants used this PDA.

The intention of this study was not to compare the different devices used, but rather to explore the impact that each device had upon the way the user carried out his or her work activities. Nevertheless, there were differences between the three devices, and these did have an effect on the way participants used them. The main difference was battery power. The Handspring operated on disposable batteries and some participants found this to be problematic; if they used the PDA extensively, they needed to change the batteries every two weeks. The Jornada, meanwhile, had a rechargeable battery that needed to be charged on a daily basis and this also caused some problems, particularly when the user was away from the office for more than a day. The Palm Vx, however, had quite a lengthy battery life and the participants who used this device seemed particularly happy with this feature.

Apart from the colour screen of the Jornada (which was viewed favourably by participants), the three devices were similar in many other respects. For example, as in Case Study A, each PDA had a pen-like stylus that could be used to manipulate icons and enter text directly onto the touch-sensitive screen. Some participants also used an attachable foldout keyboard. This enabled the user to type on a full-size keyboard, but it could only be used on a flat surface. The keyboard could then be folded away when it was not in use.

The standard software – such as the diary, address book and to-do list – was already installed on each PDA. Participants were also given instructions for downloading further software if they wished. Additional software included *AvantGo*, which enabled the user to read Internet content, such as online newspapers. Selected Internet sites could be downloaded when the PDA was connected to the desktop computer. In addition, some users chose to add WordSmith to their PDA, which enabled the Palm-based PDAs to be used in conjunction with Microsoft Word on the desktop computer, allowing users to create and store Word documents on their PDAs. This capability was already available with the standard software on the Jornada PDA.

Setting up procedure and informal observations

I conducted a brief one-to-one training session with participants when they first received the PDA. This involved assisting in the procedure of setting up the PDA, such as charging the battery, calibrating the screen, entering the time and location settings, and connecting the device to the desktop computer. It also included a brief introduction to the main features of the device. For example, I demonstrated how the pen stylus was operated on the touch-sensitive screen, how the navigation buttons could be used to open the main applications, and how to access the *home* application menu. Carrying out these training sessions enabled me to observe first-hand participants' initial reactions to the devices, and also to record any problems or breakdowns that occurred during the setting up procedure. I therefore kept a log of my observation notes of the training sessions, to which I added further notes in response to informal observations and conversations with participants that took place over the course of the study (see Appendix E for an extract of this log).

At the time of the study I was enrolled as a student in IET and so there were many opportunities to conduct informal observations of participants using their PDAs. For instance, I was able to observe people using their PDAs at department conferences and meetings, and there were many opportunities for informal conversations with participants during chance meetings in department corridors or in the university canteen. On these occasions people would often demonstrate particular applications they were using on the PDA or show me aspects of the interface that they were having difficulty with. Such serendipitous contact, then, provided further opportunities for data collection. Field notes of these encounters were recorded in a research journal and summarised in the observation log.

Email discussion

Participants also took part in an email discussion list. Like the FirstClass discussion in Case Study A, this served as an opportunity for them to share their knowledge about software and features to try on the PDA, and to help each other overcome technical difficulties. After an initial flurry of activity on the email discussion list when the PDAs were originally introduced, the contributions to the list slowed down over the course of the study and were primarily limited to those asking for help in overcoming technical difficulties. Nevertheless, these emails were helpful in identifying the device breakdowns that occurred.

Initial interviews

Semi-structured interviews were conducted approximately five months after each participant had started using the PDA. This allowed time for participants to become familiar with the PDA and to explore ways that it could be used to support their work activities. Interviews were conducted face-to-face and ranged from 30 to 60 minutes

long. All interviews were audio-recorded and subsequently transcribed. The interviews consisted of both closed and open-ended questions. Some of the questions were developed from the interviews used in Case Study A, while most of the questions were created in response to the context and specific aims of this particular case study (see Appendix F).

The closed format questions asked:

- Which features of the device participants had used.
- How frequently they had used the PDA.
- How useful participants had found the device to be.
- How easy or difficult it was to use the device (on a five-point scale).
- How easy or difficult it was to enter text on the PDA (on a five-point scale).

Open-ended questions aimed to identify participants' perceptions of the benefits and limitations of the PDA, following the notion of the task-artefact cycle (Carroll et al., 1991). The intention was to explore how the possibilities and constraints introduced by the PDA influenced how the PDA was used. Answers to open-ended questions were used as the basis for further questions, exploring how participants had used the PDA and how the PDA had changed their work activities. Therefore, as is the nature of semi-structured interviews, each set of interview questions differed slightly and the interview transcripts provided a broad and rich data set.

Follow-up interviews

Findings from the initial interviews showed that participants varied greatly in the extent to which they used the PDA and integrated it into their workplace activities. The interview transcripts were therefore examined to identify reasons for this variation. However, it was also deemed worthwhile to conduct follow-up interviews

with selected participants in order to examine these issues in more depth. Due to time constraints, only four participants were selected to take part in follow-up interviews: two who had used the PDA extensively, one who had not used the PDA at all, and one who had reduced his use of the PDA over the course of the study. The follow-up interviews aimed to provide further information about the selected participants' activity systems, so that some analysis could be made of the impact of different components of the activity system on the way the PDA had been adopted and used. These interviews consisted entirely of open-ended questions, which were developed with reference to concepts from activity theory. The interview questions shared some similarities with the Activity Checklist (Kaptelinin et al., 1999) and Mwanza's (2002) Eight Step Model, which are both methodological tools for incorporating activity theory into HCI research. However, these tools were not explicitly used when designing the interview questions; it was deemed more appropriate to prepare questions that related specifically to this research context (see Appendix G).

Final interviews

Two years after participants had been supplied with the PDAs they were contacted again by email to find out whether they were still using the PDA and, if so, how they were using it. Eight participants agreed to be interviewed again. These interviews were short and informal, ranging from 20 to 40 minutes long. A small set of open-ended questions guided each interview (see Appendix H), although the format was an informal conversation that did not follow a strict schedule. The purpose of these interviews was to find out the extent to which participants had continued using the PDAs over the course of the study and to examine the reasons why, in some cases,

the PDAs had not been fully integrated into the workplace activities. The analyses of data from this case study are presented in Chapters 5 and 6.

4.2.3. Case Study C - PDAs in NatGasCorp

This case study examined the use of PDAs in a large international organisation, known here by the pseudonym NatGasCorp (NGC). PDAs had been supplied to higher management staff at NGC three years before the study was carried out, but the technology providers were disappointed with the way the PDAs had been used (or rather, had not been used). Thus, this study aimed to explore the reasons for the limited integration of the PDA in this workplace context and it was hoped that the findings would be used to inform future decisions about mobile technology provision at that organisation. The study procedure is described below.

The workplace setting

NGC explores and markets natural gas resources around the world. The organisation was originally part of a parent company; following a demerger in October 2000 it became a distinct company which deals with the development of international business assets. These are located in countries as diverse as Brazil, Argentina, the Philippines, India, Egypt, Tunisia, and Kazakhstan. The corporation's headquarters are based in the UK, and many of the staff who work there are required to travel frequently to visit the assets and other overseas businesses. For this case study, I interviewed 16 staff members, most of whom travelled frequently and extensively as part of their job. Therefore, this organisation provided a rich context in which to examine mobile working practices and the use of mobile technologies.

PDA's and the Intranet

The initial introduction of PDAs into the organisation was motivated by the need to facilitate knowledge-sharing amongst colleagues. It was hoped that the PDAs would be valuable tools for mobile workers to maintain access to the company Intranet. Palm Vx PDAs were supplied to managers in 1999, and the company's Intranet site was made available on the Palms through AvantGo software. At the time that this case study was carried out, however, the PDAs were not being used for this purpose. The Information Technology team were in the process of replacing the company Intranet with a new Intranet portal that would provide more real-time information and be better designed to meet individual staff needs. Meanwhile, they were also intending to replace the Palm PDAs with new, higher-specification devices that, it was hoped, would provide users with a more effective mobile working tool that enabled the use of a range of powerful functions. Thus, this research took place at a time of considerable change in the provision of knowledge management and mobile working tools in NGC.

Observations

In order for me to gain further understanding of the workplace culture at NGC, I observed two staff training seminars. The first was a mobile working seminar, the purpose of which was to gain input from staff about their mobile working practices and their preferences for technologies to support the mobile aspects of their work. The seminar also involved a demonstration of some of the mobile technologies that the IT department was considering purchasing for NGC staff. The second training seminar was a demonstration of the new Intranet Portal system, which was being implemented at the time of this study (September 2002). I attended this seminar because I wanted to know more about the organisation's Intranet, which had

originally been the reason PDAs were introduced to the organisation. During both sessions, I took notes outlining the general content of the presentations, and recorded any evidence of tension or staff concerns about the technology being demonstrated (see Appendix I). Concerns were generally apparent by the questions staff asked at the end of the presentations, and the discussions people had amongst themselves. Observing these training sessions provided a good opportunity to develop my understanding of how technology implementation was carried out at NatGasCorp.

Interviews

Sixteen interviews were conducted, which each lasted from 30 to 60 minutes. They were carried out face-to-face, usually in the participant's office. There were 12 male and four female participants. The general purpose of the interviews was to identify some of the different work activities that took place at NGC, to describe the sorts of technologies used to support those activities, and, more specifically, to find out about mobile working practices at NGC and how those practices were supported by mobile technologies, particularly PDAs. All questions were open-ended and the format was semi-structured, enabling me to follow unanticipated paths during the conversation and to overlook some questions if, during the course of the interview, they appeared irrelevant. The resulting transcripts varied, therefore, in their descriptions of different work activities. For example, some interviews provided extensive illustration of the different rules and regulations of the work activity under discussion, whereas others were less detailed about rules but provided more in-depth information about the community and divisions of labour involved in the work. The results from this study are described in Chapter 7.

4.2.4. Observation Study: PDAs in the Tate Modern Art Gallery

Following the three in-depth case studies, I decided to conduct a fourth smaller-scale study which explored a further potential use of PDAs as learning tools. This final study served as an illustration of a particular context in which PDAs were being used as informal learning tools: at the Tate Modern art gallery in London. At the time, PDAs were being used on a trial basis as multimedia tour guides for visitors to the Tate Modern. I spent a day at the gallery observing the use of PDAs and speaking to visitors about how they felt about using the PDAs in this context. These methods are described further below.

Participant observation

A volunteer and I took part in the multimedia tour, using the information provided on the PDAs to learn about the artwork that was on display. The volunteer, a male 24-year-old, matched the profile of the target audience for the multimedia tours, which were aimed at younger visitors (aged 16 to 24). We both took approximately two hours to complete the tour, which was located on one floor of the gallery. I took observation notes detailing my own reactions to the PDA and the exhibits, as well as the reactions and opinions expressed by my volunteer. I also noted relevant points about the behaviour of other visitors to the gallery who were not using PDAs, as a way of contrasting the experience of using the PDA with other methods of conducting the tour. My observation notes also detailed aspects of the interface that my volunteer or I found awkward, as well as instances of technical breakdowns, and details of the features that were available on the PDA. Furthermore, I was able to observe other visitors to the gallery who were using the PDAs and, as described below, conduct a small number of informal interviews. My observation notes are included in Appendix K.

Interviews

Five interviews were carried out, including one with the volunteer I observed during the tour. The interviews were informal, semi-structured and were not recorded, although I took detailed notes. The interviews were all relatively short, lasting approximately 15 minutes each. Given the PDAs were being used on a trial basis, there were no “real” visitors taking part in the tour at the time I was there. Instead, my interviewees consisted of one visitor who actually worked at the gallery, and three visitors from another gallery who were interested to see how PDAs were being put to use in this context so they could consider implementing the same tools in their gallery. Therefore, I was not intending to report generalisable findings from this study. Rather, the study served as an illustration of a particular instance of PDA use, and provided an opportunity to speculate about how PDAs might have an impact on this informal learning activity. The findings of this study are reported in Chapter 8.

4.3. DATA ANALYSIS

As the preceding discussion has shown, most of the data for each case study derived from interviews with participants. In all, 62 interviews were conducted. These ranged in length from 15 minutes (in the Tate Modern study) to one hour, and most were audio recorded. Nine interviews were not recorded: two informal interviews in Case Study B; two interviews in Case Study C where the recording equipment failed; and the five informal interviews in the Tate Modern study. In each of these cases, however, detailed notes were recorded. All the audio-recorded interviews were also transcribed. Table 4-1 shows the notation method that was used.

Table 4-1. Notation method for interview transcriptions

Notation	Meaning
-	Mid-sentence topic change
...	Fades away
(... unclear ...)	Unclear recording; could not decipher speech
[Comment]	[Observation note or comment inserted by interviewer during transcription]
[...]	Section of dialogue deleted or not transcribed

Given the exploratory nature of this research, and the fact that most of the data were unstructured, data analysis was an iterative and reflective process that lasted throughout the project. I used a procedure that Kvale (1996) referred to as “ad hoc meaning generation”:

The most frequent form of interview analysis is probably an ad hoc use of different approaches and techniques for meaning generation. ... No standard method is used for analyzing the whole of the interview material. There is instead a free interplay of techniques during the analysis. (p. 203)

I did not use computer software to analyse the data, preferring, instead, to use a colour-coded highlighting scheme to mark on the interview transcripts; this was how I identified common themes and categories within the data. Following the approach advocated by Boulton and Hammersley (1996), the data analysis involved categorising the data and reflecting upon those categories to interpret what they meant. Activity theory concepts were greatly influential during this interpretive process. My interpretations were documented and reorganised throughout the project, and I relied heavily upon a research journal to reflect on the data and the research process itself (as recommended by Hammersley & Atkinson, 1995). In this sense, the process of data analysis was very much associated with the process of writing about the data, reflecting the fact that data analysis continued throughout the project, as is common in interview research (Kvale, 1996). As Coffey and Atkinson

(1996) argued: “Analysis is not simply a matter of classifying, categorizing, coding, or collating data. ... Most fundamentally, analysis is about the representation or reconstruction of social phenomena” (p.108). Thus, the analysis presented in this thesis primarily involved the representation and reconstruction of the stories told by the interviews, through the continual process of writing about, and reflecting upon, the interview data. The analysis methods used for each case study are described in more detail below.

4.3.1. Case Study A

Data for Case Study A consisted of both structured and unstructured data. Some of the pre- and post-questionnaire items asked for closed responses that could be quantified. Responses to these questions were entered into an Excel spreadsheet and presented in graphic form to illustrate the spread of responses. However, no statistical analyses were undertaken as this was not deemed necessary and, in line with the methodological implications of activity theory discussed in Section 4.1, such an approach would have been inappropriate.

Answers to the open-ended questions in the pre-questionnaire were examined to assess students’ expectations about the benefits and limitations of using the PDA as a learning tool. The expected benefits were grouped into two categories: “portability/mobility” and “recording notes.” Three categories of expected limitations were identified: “small screen size,” “navigation,” and “highlighting and annotating text.” These categories helped to guide the development of the post-questionnaire and interview items, and were also informative in the interpretation of the subsequent data.

The qualitative data from the post-questionnaires, interviews, and FirstClass discussion contributions were analysed together in an iterative process. Table 4-2 shows the categories that were identified from the first set of interviews, which formed the first stage of this analysis. However, not all these categories are discussed in detail in the following chapters. As Boulton and Hammersley argued, qualitative data analysis may initially involve the generation of a wide set of categories that are subsequently reduced and reorganised to reflect the continuously refined focus of the research:

One of the implications of the exploratory character of qualitative research is that the focus of enquiry is clarified over the course of data collection and analysis. Furthermore, the analytical categories used to make sense of the data . . . have to be developed in the process of data analysis. [...]

At the beginning, researchers seek to generate as many categories as possible . . . [This] is sound advice in many circumstances because it may enable the researcher to see features of the data, or of what the data refer to, that might be overlooked with a more focused approach. Such discoveries can guide the subsequent analysis.

I must point out here that I did not begin this project with the concepts of tool appropriation and tool mediation firmly in mind. Rather, a focus on these themes developed through the course of the research, and particularly when I was looking for issues that were common to the three case studies. Similarly, activity theory did not play a major role at the beginning of the research; its relevance became apparent as I analysed the initial interview data for the first two case studies. As such, activity theory concepts were applied on a post hoc basis to the themes identified in Table 4-2. Activity theory played a more central role in the analysis of the follow-up interview data, which focused more explicitly on the concept of tool appropriation. The constructs identified by the ASTAM framework, as described in Chapter 3, were used to categorise and interpret the follow-up interview data. The ASTAM

framework was also used to help elicit and analyse the follow-up interview data for Case Study B, which will be discussed further below.

Table 4-2. Themes identified in analysis of first interviews for Case Study A

Theme	Sub-category	ID	Example
Impact of PDA on reading	Portability	A03, A04, A05, A07, A09, A10	“It meant that I could read them when I only had a short period of time to read, because normally if I’m reading from the file, then I sit down and concentrate on studying, but with the PDA I had it with me all the time so that I could sit on the train or on the bus or when I had moments between meetings, and read the course materials.” (A03)
	Navigation	A01, A03, A04, A05, A07, A08, A09	“I was used to having an A4 size in front of me and being able to flick over and back if I wanted to go back to a point. ... I found that hard to do on the PDA screen initially, but it was only really a matter of adjusting to it and kind of a bit of perseverance.” (A05)
	Speed / skim-reading	A01, A03, A04, A05, A06, A07, A09, A10	“I found that I had to read it all the way through, line by line, word by word, which is completely different from the way I would normally read. So I felt like it was more plodding.” (A07)
	Taking notes / highlighting text	A03, A04, A05, A06, A07, A08, A09, A10	“I think I adopted a totally different strategy with this, there was a tendency to read it through. ... I made notes afterwards, which is slightly different to what I was doing with the paper version.” (A04)
Evaluation of interface features and usability of PDA	Screen size / screen display / text size	A01, A02, A03, A06, A07, A08, A09, A10	“if it’d got a bigger screen I’d have probably had better eyesight, then I’d have probably used it more. ... I suspect I could have used it more if it had that bigger screen capability.” (A06)
	Text input	A01, A02, A03, A04, A05, A06, A07	“Although I’m aware of Graffiti and I know it’s got the little inbuilt keyboard, it’s incredibly time-intensive and if, like me, you use a computer quite a lot it is actually much faster to type something via a computer than trying to do it via a little PalmPilot.” (A04)
Learning to use the PDA / Integrating it into activities	Adjustment – learning to use PDA, adapting PDA to suit preferences, adapting study practices	A01, A04, A05, A06, A07, A09, A10	“The main thing for me is that it’s a new tool so I think what I wasn’t prepared for was how much I’d have to rethink my study strategies. I think that’s the thing. It’s more than just a different way of doing things, it actually alters the way you approach your studying.” (A10)
	Prioritisation of learning to use PDA	A02, A04, A05, A06, A08, A10	“It came at a highly pressured time and trying to learn to do the Palm as well as do the studying when you’ve got your examinable component hanging over your head, was quite a lot to think of.” (A08)
	Technical difficulties	A01, A04, A06, A07, A09	“I did think, oh god, this is not going to work, it’s going to cause me extra trouble and my machine is going to crash and everything. But none of those things

			happened and I did find it very easy.” (A07)
	Affective responses	A03, A04, A09	“I enjoyed using it. I certainly did. It was a great opportunity because I would never have bought one myself.” (A05)
Other uses / potential uses	As learning tool	A01, A03, A05, A07, A09, A10	“The main attraction for me was originally to be able to synchronise the online discussion because of travelling around. And to be able to respond to the questions and the discussions and then when I got access to computers to be able to send them through.” (A01)
	As workplace tool	A02, A03, A05, A06, A08	“I certainly used it a bit for work. I used it for note-taking, I used the calendar which I do find useful [...] There are times when obviously I am away from the office so it was easier. I now put my appointments in the calendar and use it that way, you know, download it from my work’s PC. And the to-do list and the notepad I tend to use quite often.” (A06)
	As personal tool	A02, A03, A04, A05, A09	A03 uses AvantGo to download newspapers and articles from the Internet. A05 has found PDA very helpful for recording URLs
Other tools	Comparison with other technologies	A02, A04, A06, A09	“If I want to call up several documents and have them all in various windows at the same time and send emails and be on the Net – you can do all of those on the laptop.” (A02)
	Using PDA in conjunction with other tools	A04, A07, A08, A09, A10	“I see it as a tool to be used in conjunction with a computer, not instead of.” [...] “There are certain things in retrospect now I would have done on the computer and just copied over to the PalmPilot rather than doing it on the PalmPilot and then copying it over to the computer.” [...] (A04)
	The PDA overcoming limitations of other tools	A04, A05, A06, A08, A09, A10	“The only problem with the paper version, with A4, you have to take it out of its binder if you want to transport only just one section. Otherwise you’ve got this huge binder to carry around with you. So from that perspective, I like its portability.” (A04)
	The PDA in conflict with other tools	A02	Other tools existed that did things better than PDA: “a PDA didn’t offer me anything that I didn’t already have in another form somewhere else.” (A02)

4.3.2. Case Study B

I adopted a similar approach when analysing data from Case Study B. Indeed, given that these two studies took place concurrently, the analyses were closely linked, and similar themes were identified. The initial categorisation of data from the first set of

interviews is summarised in Table 4-3. Activity theory concepts were then used to help interpret the data, particularly with regard to how the PDA appeared to change the activities it was used to support. The results of this analysis are described in Chapter 6.

The sub-categories that made up the theme “integrating the PDA into work activities,” as shown in Table 4-3, informed the development of interview questions for the subsequent interviews. This initial analysis also contributed to the development of the ASTAM framework. The ASTAM framework was used to analyse the full set of interviews to determine how different social factors appeared to influence the way the PDA was used. This analysis identified issues relating to each of the constructs in the ASTAM framework (subject, tools, rules, community, division of labour, object, outcome). The results of this analysis are described in Chapter 5.

Table 4-3. Themes identified in analysis of first interviews for Case Study B

Theme	Sub-category	ID	Example
How the PDA was used	Diary / time management	B02, B03, B04, B05, B06, B07, B08, B09, B10, B11	“I gave up trying to keep two diaries so having a PDA is quite nice because I don’t see it as keeping two diaries, I see it as just taking my existing diary with me.” (B02)
	Note-taking / aide memoir	B02, B04, B05, B07, B08, B10	“It is very useful for short notes to myself. ... I’m using this like a little notebook all the time.” (B10)
	Email	B01, B03, B04, B07, B08, B11	“The only thing I’d done really was to download emails, take them into a meeting and read them during the meeting in quiet points where I wasn’t required to contribute.” (B01)
	Other uses / potential uses	B02, B03, B07, B08, B09	“What I’d really like to try and experiment with is the web side of things, the AvantGo side of things.” (B02)
Benefits of PDA	Portable	B02, B03, B04, B05, B06, B07, B08, B09	“It just enables you to make use of little pieces of time.” (B09)
	Personal	B02, B07, B10	“the PDA is really personal. I don’t have to worry about it, I can include personal documents on it. It’s not heavy-duty personal stuff, just things like what do I

			need from my shopping. With a desktop or a laptop you can actually worry about the integrity of what you're doing." (B07)
	Electronic data / compatibility with computer	B02, B04, B05, B06, B07, B08, B09, B10	"I've scribbled notes in a meeting, and then come back to make notes from the meeting and of course they're now in electronic format as the outline for what becomes the word document that I just copy and move over." (B10)
Constraints of PDA	Text input methods	B01, B02, B03, B06, B07, B08, B10	"It takes an awfully long time. The hunt and peck keyboard thing where it shows you the keyboard and you tap out the letters is very fiddly and takes a long time to do. And the handwriting recognition I didn't get on with, I found it even slower." (B06)
	Small screen	B01, B02, B03, B04	"I think screen size is critical ... the amount of information that can be displayed intelligently on the screen is a big limiting factor." (B02)
	Battery life	B02, B03, B04, B05, B07, B08	"I went on a trip to the states for a fortnight and expected to be able to use my PDA at least part of the time and it both completely went flat and went so flat the whole thing had to be re-initialised and restarted and all of the data was lost." (B08)
Integrating PDA into work activities	Past experience	B01, B03, B04, B05, B07, B11	"I did secretarial training at one point in my career, did short hand and all that sort of stuff. So you just get used to using pencils or pens or styluses in a particular way, and you can just do it." (B04)
	Personal preferences	B01, B02, B04, B06, B07, B09	"There's something about the way in which aesthetic considerations lead into emotional responses, like, even though I've never used a Mac in my life but it's why I say the iBook is so wonderful on television and why laptops I think are very attractive items, particularly if they've got a nice metal case. But I didn't build up that sense of attractiveness of the PDA." (B01)
	Existing work practices	B01, B02, B04, B05, B07, B08, B09, B10	"I'm a back of the envelope person and some of my most successful work ideas have been written on the back of envelopes and serviettes." (B02)
	Community knowledge	B01, B02, B04, B05, B07, B08, B09, B10, B11	"I found the Graffiti a bit irritating and read various things in the press ... I suppose it was partly other people also seemed to be finding it irritating so I thought right, okay, something better will come along and I'd rather wait than do it with this." (B01)
	Time / inclination to use PDA	B01, B03, B04, B05, B09, B10	"I think it's worthwhile taking the time to set things up properly and then you get a lot more out of it. And I'm quite prepared for that. I think some people don't think it's worth it." (B09)
Other technologies	Comparison	B01, B02, B03, B04, B07, B08, B09	"I think there's something very organic about scribbling on bits of paper. The bits of paper themselves are significant. They are a certain shape or a certain colour or a certain context and that's something that's quite difficult to replicate electronically."

			(B02)
	In conjunction with	B01, B02, B03, B05, B06, B08, B09, B10, B11	“I see the PDA as taking bits of my computer with me when I go.” (B02)
	In conflict with	B04, B07, B10	“I wanted to be able to come in and have my desktop and my laptop telling me the same things and then I wanted to be able to walk around with the Handspring telling me the same things too. But trying to get these three devices to talk to one another proved difficult.” (B04)
Dependence on the PDA		B01, B03, B06, B07, B08, B09, B10	“I mislaid it for a couple of days and realised I did rely on it.” (B03)

4.3.3. Case Study C

The analysis of data in Case Study C was influenced at the outset by activity theory. Activity system triangles were drawn to represent the main work activities that each interviewee described (see Figure 4-1 for an example). Although these triangles are not referred to in the discussion of this study (Chapter 7), they were extremely helpful in clarifying the data and describing the work activities at NGC, giving me a sound understanding of the workplace context upon which to base my interpretations. This method of analysis also helped to reveal contradictions in the activity systems in relation to the use of mobile technologies in NGC. The interview transcripts were then examined to determine what they revealed about mobile working practices at NGC. Activity theory concepts were used to help interpret the data. The ASTAM framework was also used during this analysis to help understand the process of tool appropriation in this context. As in the analysis of the follow-up interviews in the first two case studies, the ASTAM framework was used here to help categorise and interpret the interview data.

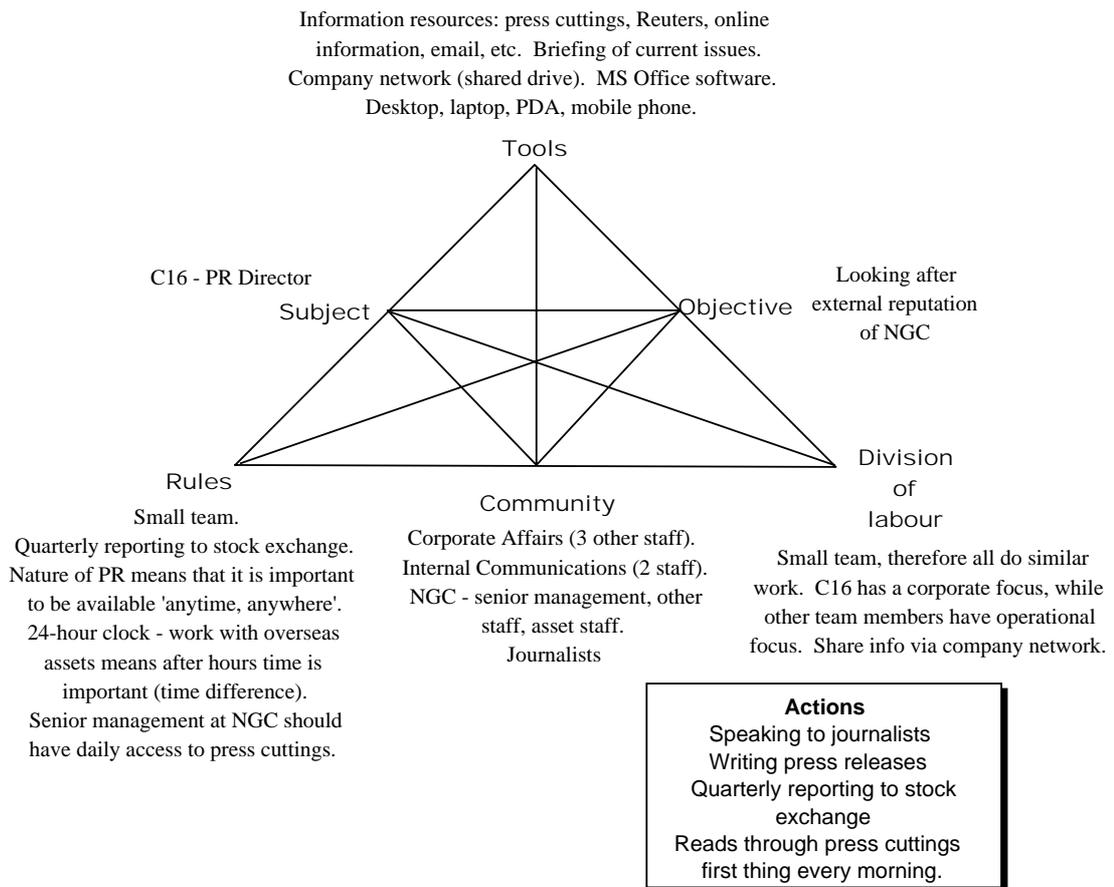


Figure 4-1. An example activity system analysis from Case Study C

4.3.4. Tate Modern observation study

The observation study of PDAs in use at the Tate Modern art gallery differed from the three main case studies in that it was smaller in scale, serving as an illustrative example of PDAs in use. This study, therefore, was descriptive rather than analytical. Chapter 8, which reports the findings of this study, describes my own experiences of using the PDA in this context, as well as reporting the reflections of the other visitors I spoke to. The data elicited from this study were not subjected to continual analysis as in the previous studies. However, the concepts and themes that

emerged from the previous studies doubtless influenced my interpretations as I noted, and reflected upon, my observations during this study.

4.4. CONCLUSION

This chapter has described the methods used in each of the case studies presented in this thesis. As recommended by activity theory, the case studies involved qualitative research methods, consisting primarily of interviews and other self-report methods such as questionnaires and online discussions, as well as both formal and informal observations. The findings from each case study have been subjected to iterative analyses based on activity theory concepts. The results from these analyses are presented in the following four chapters. Thus, having concluded the discussion of the methodology and methods that contribute to this research, it is now time to turn to the findings of each study.

Chapter 5

An Activity System Analysis of Tool Appropriation in Case Studies A & B

The purpose of this chapter is to address the first research question of the thesis: how are PDAs appropriated as learning and workplace tools?

In response to this question, I examined the data from Case Studies A and B to explore the reasons behind the variation in the way participants had used the PDA. As described in Chapter 3, it was helpful to analyse tool appropriation as an activity in itself, using the *Activity System Tool Appropriation Model (ASTAM)*. This framework enabled me to assess how the different components in the activity system (subject, community, tools, rules, division of labour) had an effect on the way the PDA was appropriated by participants in each study. The findings of this analysis are presented later in the chapter. First, though, Section 5.1 will describe how the PDAs were used in Case Study A, while Section 5.2 will outline the use of PDAs in Case Study B. This is the first of two chapters that present data from the first two case studies. Chapter 6 will examine how the PDA mediated the activities it was used to support in these studies.

5.1. CASE STUDY A - HOW THE PDA WAS APPROPRIATED AS A LEARNING TOOL

Students who took part in Case Study A were supplied with the PDA for a specific purpose: to read course materials. However, many students used the PDA to support other aspects of their learning, workplace and family activities. This section describes students' expectations and evaluations of the PDA, and reports the uses students said they made of the PDA, drawing on data from the pre- and post-questionnaires, interviews, and online conference contributions.

5.1.1. Expectations

The pre-questionnaire, which was returned by 44 students, asked how useful students believed the PDA would be for reading course materials. Figure 5-1 reveals that the majority of respondents (29 students – 66%) believed the PDA would be *somewhat useful*. Students were also asked why they believed the PDA would or would not be useful for reading course materials. Those who believed the PDA would be useful felt that the portability of the device and the ability to record notes electronically would be the main benefits. Conversely, other students were concerned that the screen size would be too small, and that it would be difficult to navigate through documents and to highlight and annotate texts.

Students were also asked “in what other ways do you hope to be able to use the PDA to support your study activities?” Sixteen students said they would like to use the PDA as a note-taking tool, while many students also said they would like to use the PDA to support time management, and as a facility for downloading and storing important information, such as tutor contact details, useful URLs, web resources,

references, and other documents. As discussed below, some students did make use of the PDA to support these activities.

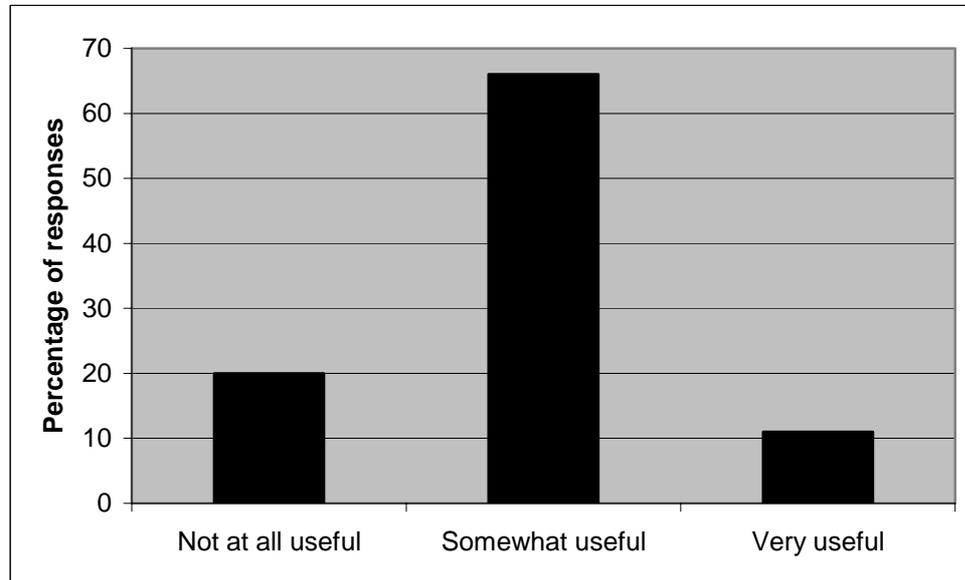


Figure 5-1. Pre-questionnaire responses to the question "How useful do you believe the PDA will be for reading course materials?" *

*(N=44). One respondent, however, did not answer this question.

5.1.2. Interviews

Table 5-1 summarises the information provided by the interviewees. As shown, each interviewee has been given an identification number. The identification numbers begin with a letter that signifies whether the participant took part in Case Study A, B, C or D. In each interviewee table (in this and the following chapters), an M or F is added to the ID numbers to indicate whether the participant is male or female. These ID numbers will be used throughout the thesis when referring to comments made during the interviews. Where comments are taken from the open-ended questionnaire items and FirstClass contributions, they are simply identified as belonging to a "questionnaire respondent" or "FirstClass contribution" respectively.

Table 5-1. Information provided by Case Study A interviewees

Participant	First Interview*	Follow-up Interview**
A01 M	Used PDA briefly to read course materials but reverted to printed texts. Did not like text size on screen and preferred annotating text on paper.	
A02 M	Did not use PDA to read course materials. Found the device too small.	
A03 F	Used PDA to read course materials. Also used it as a workplace tool (calendar, address book, note-taking, downloading web sites).	
A04 F	Used PDA to read course materials. Also has own Palm PDA.	Uses own PDA (Palm V) as personal and workplace time and information management tool (calendar, recording birthdays, downloading emails, to-do lists)
A05 F	Used the PDA to read course materials. Also tried out other features.	
A06 M	Did not use the PDA to read course materials. Tried but did not have time to learn to use it during the course. Used the PDA as a work tool (note-taking, calendar).	
A07 F	Used PDA to read course materials. Also used it for other learning activities (e.g., downloading FirstClass Conference messages).	
A08 M	Did not use PDA to read course materials. Tried but gave up because screen size was too small. Used it as a workplace tool (to-do lists, calendar, contacts).	
A09 F	Used PDA to read course materials but had to give up due to eye-strain problems.	Uses own handheld computer (Psion Revo) as personal time and information management tool.
A10 F	Tried to use PDA to read course materials but found it difficult so reverted to using printed documents.	
A11 M		Uses own PDA (Handspring) as a workplace and learning tool (diary, address book, emails, reading material). Also made many contributions about this to the FirstClass conference discussion.
A12 F		Uses own PDA (Hewlett Packard Jornada) for personal and work activities (leisure reading, meeting notes)
A13 F		Uses PDA supplied for course as a learning and workplace tool (calendar, reading course texts, note-taking). Also made many contributions about this to the FirstClass conference discussion.
A14 F		Used PDA supplied for course as workplace and personal tool (calendar, address book, calculator, memos - e.g., shopping lists). However, had stopped using PDA because work computer had

		been upgraded and could not be connected to PDA.
A15 F		Used PDA supplied for course as a work tool (address book, to-do lists, memos). At the time of interview had lost PDA but was planning on buying a new one.
A16 M		Did not use PDA. Found the screen size too small and prefers reading text on paper. Resistant to this and other technologies (e.g., mobile phone).

* Students who took part in the first interviews were selected from the entire cohort of students. This selection was intended to represent the different tutor groups that make up the course. The first interviews took place at the end of the course in October 2001, approximately two months after students had received the PDAs.

** The students who took part in the follow-up interviews had responded to an email sent out several months after the course had finished, and volunteered to take part in the interview. The follow-up interviews were carried out in July 2002, approximately one year after students had received the PDA.

As shown in Table 5-1, only two of the students who took part in the first set of interviews volunteered to take part in the follow-up interviews. While it would have been helpful to conduct a follow-up interview with each of the initial participants, unfortunately this was not possible. This is one of the inevitable consequences of relying upon voluntary participation in an interview study such as this; availability of interviewees will always be an issue that impacts upon the extent and type of data collected in such a study.

5.1.3. Students' use and evaluation of the PDA

As can be seen in Table 5-1, the students who took part in the interviews varied in the extent to which they used the PDA and the particular uses they made of it. To further illustrate this, Figures 5-2 and 5-3 show the spread of responses from the post-questionnaire items that asked students to indicate how often they used the PDA to read course materials, and which other features of the device they used. As can be seen in Figure 5-2, only a small percentage of students used the PDA more than once a week to read course materials. Meanwhile, as shown in Figure 5-3, many students used the more generic features of the PDA, such as the address book, to-do list, and

diary. However, the questionnaire did not elicit any information about how often these other features were used.

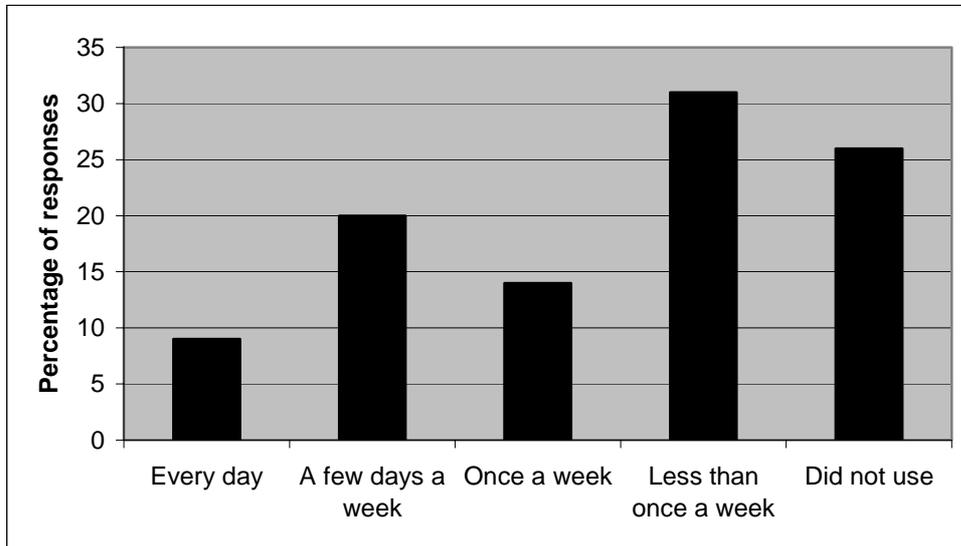


Figure 5-2. Responses to the question “How often did you use the PDA to read course materials?” *

* (N=35)

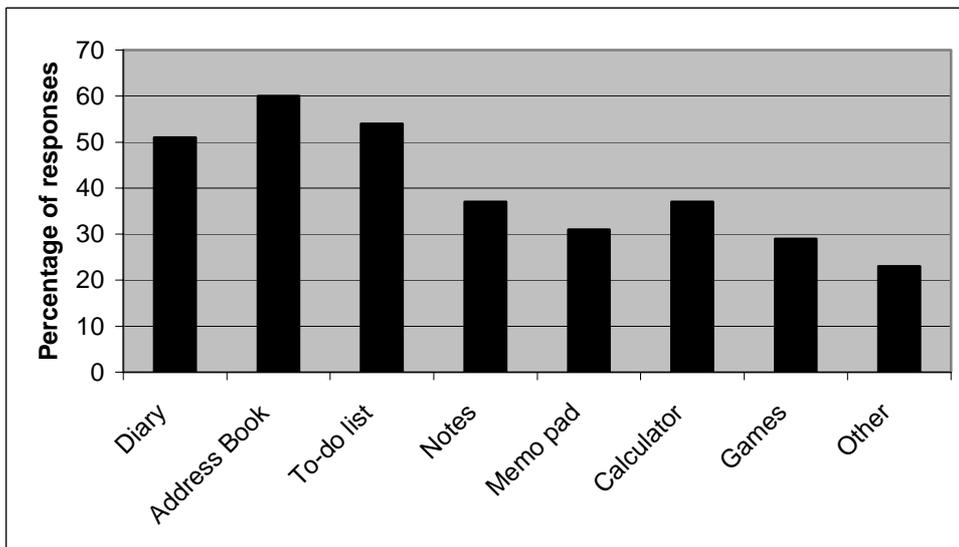


Figure 5-3. Responses to the question “What other functions of the PDA did you use?” *

* (N=35)

Students were also asked to assess how useful they found the PDA to be as both a reading tool and a general purpose device. Figure 5-4 illustrates the percentage of respondents who said they found the PDA *very useful*, *somewhat useful* or *not at all useful*. As can be seen, students found the PDA more useful as a general purpose tool, with 14 respondents (40%) saying they thought it was *very useful* in this context, compared with just six respondents (17%) who said the PDA was *very useful* for reading course materials.

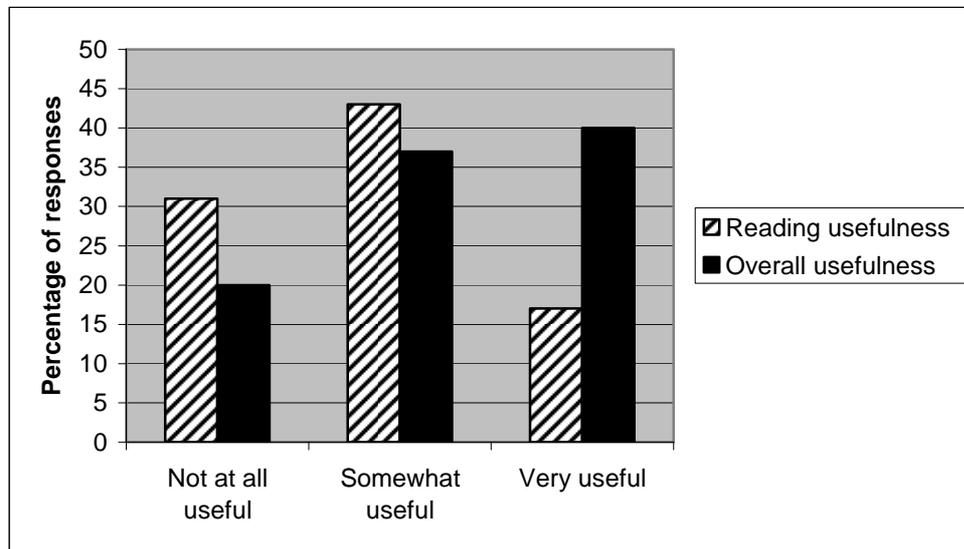


Figure 5-4. Ratings of the PDA’s usefulness (a) for reading course materials and (b) overall *

* (N=35). However, three respondents did not answer the “reading usefulness” question, while one respondent did not answer the “overall usefulness” question.

The interviews and FirstClass conference discussions also revealed further uses that students had made of the PDA and how it consequently altered the activities it was used to support. These further uses were discussed in more detail in the follow-up interviews, as shown in Table 5-1, which mostly involved students who were enthusiastic about the Palm PDA – or a similar device that they had bought themselves – and used it extensively as a learning, workplace or personal tool.

Therefore, the following sections, which describe these uses in more detail, may appear to present a “pro-innovation bias” (Rogers, 1995). This is unintentional and reflects the fact that these accounts represent the data provided by the more enthusiastic PDA users who took part in this study.

5.1.4. The PDA as a learning tool

In addition to using the PDA to read course materials, which will be described further in Chapter 6, some students also used it (or their own handheld computer) to support other aspects of their learning activities. For instance, a small number of students used the PDA as a note-taking tool, not only while reading the course texts provided on the PDA, but also when reading the printed course materials, or while preparing for an assignment. The PDA made it possible to record electronic notes while students were away from their home or office. Unlike hand-written notes, these notes could be easily transferred to the desktop computer, without the need to type them up. Some students exploited this capability by using the PDA to jot down notes when they were preparing to write a course assignment. Portability was a key benefit here, enabling students to capture thoughts relating to the assignment whilst otherwise engaged in separate activities:

When it's coming up to TMA [Tutor Marked Assignment] time you find that you've got thoughts about it starting to float around your head so it's quite handy if you're in the middle of Sainsburys or something and you suddenly think of something, it's quite handy to just get this out and make a quick note which you can then work on later. (A13)

In addition, some students downloaded notes from the computer to the PDA so they could have “anytime, anywhere” access to their current documents. Similarly, some interviewees said they downloaded other course texts onto the PDA (in addition to

those already made available) and copied extracts from FirstClass conference messages to store on the PDA. Such uses would have required some ingenuity on the part of the user: the student would have had to initially copy the FirstClass messages into a word document before being able to download them onto the PDA. Many students expressed an interest in using their PDA to access FirstClass messages. I explored the possibility of doing this, but unfortunately at the time there was no software available to synchronise the PDA with the FirstClass conference.

5.1.5. The PDA as a workplace tool

The PDA proved to be useful for many students as a workplace tool. In fact, some of the interviewees who did not use the PDA to read course materials or to support any other learning activities said they did make use of the PDA extensively as a workplace tool. It was particularly valuable for supporting workplace time and information management. Again, the fact that the PDA could be synchronised with the desktop computer was an advantage in this situation. Some students used a calendar facility on their workplace computers, which could then be downloaded onto the PDA, overcoming limitations of existing tools:

I was getting into trouble with duplicating my Outlook calendar with my hand-written diary, and not always remembering to transfer appointments from one to the other. ... If you have a paper diary it can get out of date with your Outlook one, whereas the Palm just synchronises and it's all sorted for you. You don't have to enter in things twice. So it's really useful for that.
(A14)

The PDA, then, provided a portable electronic diary that could be used in conjunction with the Outlook calendar on the desktop computer, which many students used as a time-keeping tool in the workplace. Because the PDA was lightweight and portable it could be taken into meetings and used in other situations

where users might be away from the main computer. This was a particularly valuable use of the PDA, and is discussed further in Chapter 6 with reference to Case Study B.

Furthermore, some students used the PDA to record notes in meetings, which could then be uploaded onto the main computer and stored for future reference or further work. Again, the compatibility of the PDA with the desktop computer made it particularly valuable in this situation, reducing the need to replicate actions: “I would go to meetings and write notes and then come back to the office and type them up. But now I don’t have to do that very much” (A12). In addition, students used the address book, memo-pad and to-do list functions on the PDA to store key information. In this respect, the PDA was seen as an extension of the user’s memory (“I just use this as my brain really.” - A14), leading to a sense of reliance upon the device.

Similarly, one student who took part in both the initial and follow-up interviews used her own Psion Revo, a handheld computer, to store all important information relating to her personal and family life. She relied upon her Psion as an information management tool: “My whole life is in that little thing. It goes everywhere with me” (A09 - first interview). This student’s extensive use of her PDA as a family management tool is described further below.

5.1.6. The PDA as a personal tool

Jane (A09) was one of the more enthusiastic PDA users in this study, although she was unable to use the Palm m105 to read course materials due to eyestrain problems (this is discussed further in Section 5.3.5). Nevertheless, her case is particularly

interesting as an example of how one person has adopted and used a PDA, demonstrating how the device fits in to her lifestyle and is valuable as a tool for organising family activities. Jane used her PDA as a family time management tool, to keep track of finances and to store important personal information. The PDA completely replaced the paper tools that she previously used to support these aspects of her life. Although she had found her paper diary to be “absolutely perfect” and was “quite resistant” to the electronic tool, when given the Psion as a gift she found that it overcame limitations of paper tools and was, ultimately, a better solution:

Because everything I need to do is in the one thing. I know if I grab my handbag and I shove my Psion in it – and it’s quite small, it fits quite well in all my handbags – I know I have everything that I might possibly want or need, whereas with a paper diary you don’t have the spreadsheet function, you don’t have the alarm function... (A09 – follow up interview)

Furthermore, the PDA diary could be used to change repetitive diary entries – such as whose turn it was to collect the children from band practice, a task that was shared with other parents. Previously, if this information had to be amended, Jane would need to go through her paper diary and change the entry for each week individually. With the electronic diary, when one entry was changed the following entries would be updated automatically. Jane also used the PDA to share schedule information with her husband, who used a compatible device for his own time management tasks. Furthermore, she used the PDA to make a note of telephone messages – “then I know I won’t lose it” – and to jot down information that she wanted to record, such as the name of a garden plant that she liked and wanted to remember. In this respect, the PDA was a personal learning and information management tool, aiding the user to keep track of a wide array of items.

Other students said they used the PDA to download texts for leisure reading or for personal interest. For instance, some students used AvantGo, or other web-clipping software, to download newspapers from the Internet onto the PDA, while others read electronic books on the PDA. One student, who used his own Handspring PDA, said he had approximately one hundred pages of poetry on his device, which he had obtained from *Project Gutenberg*, a web site that enables people to access electronic copies of out-of-print materials. Similarly, another student said she would download novels, short fiction and poetry onto her PDA (she used her own Hewlett Packard Jornada, a Microsoft device that has a colour screen). She found that when using this device as a reading tool – for both personal reading and OU course materials – it changed the way she interacted with the text, particularly if the materials were available as Word documents. In this case, she would modify the text, creating her own document:

For those things that I've got just as word documents, whereas in the past I would just read them and scribble on the bits of paper maybe, now I would actually tend to change them more. Move around the text, almost start creating a new story for myself. I'm interacting with the text in a slightly different way in that sense. It's an object which I can now change and I think I own it so I can muck around with it. (A12)

This is similar to the way some students used the PDA when reading the Study Guide: they copied text from the course materials in order to extract key points from the document. However, as will be described further in Chapter 6, many students found it difficult to read and interact with the course materials on the PDA. Interestingly, those students who took part in the follow-up interviews who continued to use a PDA as a reading tool all used a device that they had bought themselves – not the Palm m105 supplied in this study. The PDAs they had bought

were more expensive than the one used in the study, and had slightly bigger and better quality screens. It is possible, therefore, that more students would have made use of the PDA as a reading tool had the device chosen for this study been better designed for this purpose.

Moreover, the students who said they used their PDAs as reading tools did not feel that the new device had replaced paper. Instead, they continued to read printed documents and paper novels, but used the PDA in situations where paper was impractical, such as on the train: “When you’re crammed in between two people, it’s easier than getting out a laptop or reading a newspaper. It’s smaller than any of those things. So you can read it in really confined spaces” (A11). As such, the PDA was not considered a stand-alone tool. Most interviewees who used a PDA used it in conjunction with other technologies, as an auxiliary to existing tools. This was also the case in Case Study B, described further below.

5.2. CASE STUDY B - HOW THE PDA WAS APPROPRIATED AS A WORKPLACE TOOL

In Case Study B, participants primarily used the PDA as a time and information management tool in the workplace. As described in the previous chapter, this study took place in an academic workplace setting, in the Open University’s Institute of Educational Technology (IET). The work conducted in such settings is typically information-based, or *knowledge work* (Blackler, 1995). That is, it involves reviewing, producing and distributing information, which in IET means preparing course materials for Open University students, conducting research and course and institutional evaluations, preparing reports of this research, and presenting

information to colleagues in meetings or at academic conferences. Therefore, participants in this study were involved in numerous projects and work groups. In addition to being part of the departmental and institutional community, some staff members were also involved in cross-departmental work groups, such as course teams, and cross-institutional work groups, such as collaborative research projects.

In order to manage their involvement in multiple projects and teams, participants had to keep track of numerous deadlines and appointments, and exchange much information with colleagues. Most participants were office-based, although they also often worked from home and some travelled extensively to other institutions to meet colleagues or attend conferences. Therefore, there was a clear need for a portable time and information management tool in this workplace setting.

5.2.1. Expectations

Participants volunteered to take part in this study because they wanted to try out the PDA to explore its potential as a workplace tool. Before the study began, participants were contacted by email to determine what features and functions of a PDA they hoped to use, in order to inform the decision about which devices and accessories to purchase. Some participants said they wanted to be able to use a keyboard with the PDA (hence, some attachable foldout keyboards were purchased). In addition, the email responses included many references to the potential use of PDAs as communication tools. One participant was particularly keen to explore the use of PDAs to support collaborative working via a wireless network. While this would have been an interesting and potentially valuable use of the PDA, the funding for the project only covered the purchase of a small number of devices; there was no funding available to install a wireless base station or purchase wireless network cards

for each PDA (at the time, PDAs with wireless networking capabilities were not widely available).

5.2.2. Interviews

As discussed in Chapter 4, this study took place over two years. In that time, three sets of interviews were conducted: initial interviews with all participants (which took place approximately five months after participants had begun using the PDAs), follow-up interviews (10 months after PDAs were introduced) with four selected participants who varied in the extent to which they had adopted the PDA, and final interviews or informal conversations with available participants to find out how their use of the PDA had evolved over the two years. Table 5-2 summarises the information provided at each interview. Again, participants varied in the extent to which they used the PDA, although most were enthusiastic about it and used it to support key aspects of their time and information management activities.

Table 5-2. Information provided by Case Study B interviewees

Participant	PDA given	First Interview*	Follow-up Interview**	Final Interview***
B01 M	Handspring Visor	Does not use PDA. Wanted to use it to read emails but did not find it useful for this purpose.	Discussed reasons why PDA had not become a useful tool.	
B02 M	Handspring Visor	Enthusiastic about PDA. Uses it primarily for diary and contact details. Sometimes uses it for note-taking but prefers paper. Carries memos and word documents on PDA.	Initial enthusiasm for PDA had waned because of the need to constantly replace battery. Gave up using it for a while but found that he needed it for the electronic diary.	Informal conversation: Has changed jobs and moved away from the OU; therefore no longer has OU PDA. Bought own inexpensive PDA to use for electronic diary.
B03 F	Handspring Visor	Uses PDA for diary, address book, emails and calculator. Found it particularly useful for checking emails at the end of the day. Would like to use it to access Internet		Initial PDA had been destroyed in an accident and was replaced with a HP Jornada. However, this was never installed properly as the software disk

		resources such as bus timetables.		was missing so B03 did not continue using a PDA and reverted to other tools such as a paper diary.
B04 F	Handspring Visor	Initially found the PDA useful but at the time of the interview she had stopped using it because the batteries had run out. Could not synchronise PDA with both desktop (PC) and laptop (Mac) computers.		
B05 M	Handspring Visor	Enthusiastic about PDA. Uses diary, address book, to-do lists, and note-taking.		Still using PDA, although had recently lost it for a few weeks. Uses it to record personal memos and has downloaded some sketch applications.
B06 M	HP Jornada	Enthusiastic about PDA. Uses diary, to-do lists, emails, e-books.		Still uses PDA. Has experimented with different applications over time.
B07 M	HP Jornada	Enthusiastic about PDA. Uses diary, address book, to-do lists, note-taking, emails, editing word documents. Previously used Palm PDA.		Informal conversation: On secondment at another organisation. No longer uses HP Jornada but current employer has provided a mobile phone with integrated PDA.
B08 F	HP Jornada	Enthusiastic about PDA. Uses it for diary, address book, note-taking, emails, Internet, word documents.		Stopped using PDA because of battery life problems. Has begun using it again but not as much as at first interview.
B09 F	Palm Vx	Enthusiastic about PDA. Uses it for diary and also in combination with foldout keyboard to take extensive notes in meetings and seminars.	Still enthusiastic about PDA. Although she has experienced technical difficulties, this has made her cautious but has not waned enthusiasm.	Is no longer a member of staff, now a full-time PhD student. Still uses PDA extensively, e.g., to take notes during PhD training sessions, to keep track of references using Endnote (reference software)
B10 F	Palm Vx	Uses PDA extensively for diary, address book, to-do lists, note-	Still enthusiastic about PDA and has continued to use it in the same	Still uses PDA for diary but reduced use of it because of

		taking, calculator.	way.	screen calibration problems. In process of replacing current PDA with new similar device.
B11 F	Palm Vx	Uses PDA extensively for diary, address book, to-do lists, emails.		

*All participants took part in the initial interviews, which took place in October and November 2001, approximately five months after PDAs had been introduced.

**Due to time constraints, only four participants were selected to take part in the follow-up interviews, which took place in April 2002, approximately 10 months after PDAs had been introduced.

***8 participants responded to a follow-up email and agreed to take part in a final interview. These took place in November and December 2003.

5.2.3. How participants used the PDA

During the first set of interviews, participants were asked a set of closed questions (in addition to open-ended questions) that aimed to elicit information about how they had actually used the PDA. Figure 5-5 illustrates the functions of the PDA that participants said they had used. As can be seen, they made use of a variety of functions, the most common being the diary, or calendar, which is clearly a time management tool. They also used the PDA to read and write emails, to store telephone numbers in the address book, to record and store notes, to edit word documents, and to download Internet content such as newspaper articles. Each of these functions could be considered part of the general activity of information management. In addition, some people made use of the calculator feature on the PDA and some also used the device to play games. Several participants used their PDAs to “beam” information to other PDAs, through the infrared connection. However, during the interviews it transpired that most participants did this just once as an experiment to see how it worked.

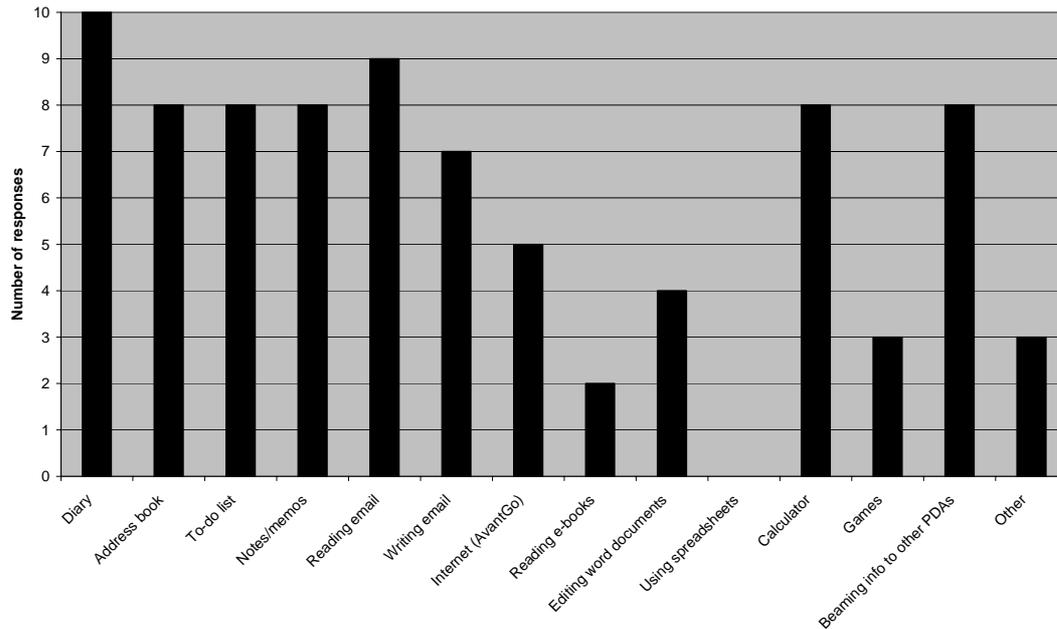


Figure 5-5. PDA functions used by participants in Case Study B*

* (N=11). NB: Participants used different PDAs and so some applications were not available on all PDAs (for instance, e-book reading software was only available on the HP Jornadas)

5.2.4. Evaluation of PDA usefulness

Participants were also asked how useful they had found the PDA to be; eight participants said it was *very useful*, two said it was *not at all useful*, and one said it was *somewhat useful*. Of those who said it was not at all useful, one (B01) had decided early on not to continue using the PDA because it did not sufficiently meet his needs, while the other (B04) had temporarily stopped using the PDA at the time of the interview due to a combination of insufficient battery power and the inability to synchronise the PDA with both her PC desktop computer and her Macintosh laptop. Therefore, at the time of the first set of interviews, all other participants had found the PDA to be a valuable tool, and most used it on a daily basis (nine participants said they used the PDA every day). However, as shown in Table 5-2, this initial enthusiasm and daily use waned for some participants over the course of

the study. Section 5.3, below, discusses some of the reasons for the variation in the way participants in both studies used the PDA, based on an activity system analysis of tool appropriation.

5.3. AN ACTIVITY SYSTEM ANALYSIS OF TOOL APPROPRIATION

In this section, I examine how contextual factors influenced the way the PDA was appropriated by participants in both Case Studies A and B. I have chosen to analyse these studies together because they both tell a similar story about the process of tool appropriation. Although the PDAs were used in different settings in each study, there appeared to be similar factors influencing how the PDAs were used. These factors can be identified by the *Activity System Tool Appropriation Model (ASTAM)*, which was introduced in Chapter 3. Figure 5-6 illustrates the analysis based on this framework. In the figure, key themes that emerged from the interviews, online discussions, and questionnaires in each study, are mapped onto the components of the activity system triangle. Each of these components is described, in turn, below, drawing on data from both studies to exemplify this analysis.

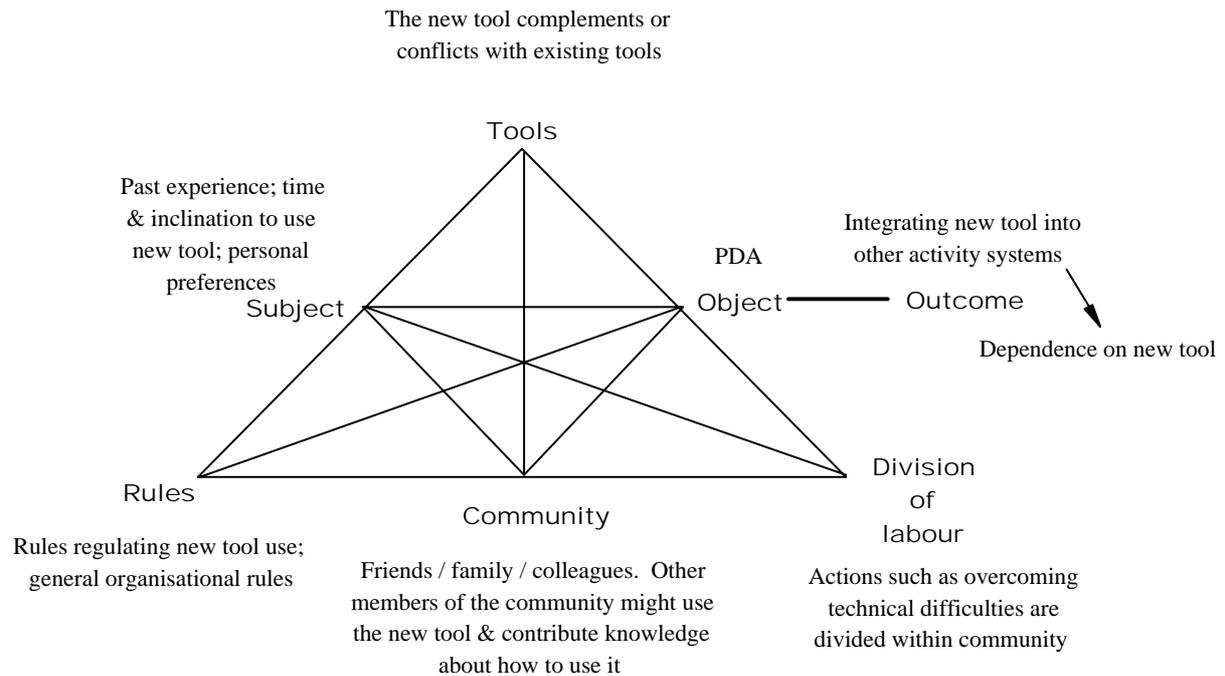


Figure 5-6. Analysis based on ASTAM framework

5.3.1. The subject

As discussed in Chapter 3, it is assumed in this thesis that the subject in an activity system is an individual person rather than a group of people. Therefore, each participant in the case studies presented here had his or her own activity system of tool appropriation. Due to insufficient space, however, it is not possible to examine in detail each of these activity systems. Rather, the following discussion will look at some of the past experiences, personal circumstances (i.e., time and inclination to use the PDA), and personal preferences that appeared to have an effect on the way participants responded to, and appropriated, the PDA. These are the themes that emerged from an analysis of Case Studies A and B which, as shown in Figure 5-6, can be mapped to the “subject” component in the ASTAM framework.

Past experience

The influence of past experience was particularly apparent with respect to how people adapted to using the new limited text input methods on the PDA, especially the hand-writing recognition systems such as Graffiti. A common basis of comparison was touch-typing on a computer keyboard. For example, one participant in Case Study B (B11) had previously used a Psion handheld computer, which had an integrated keyboard but no handwriting recognition system. As this participant was not a touch-typist, she found the reliance upon a keyboard for data entry on the Psion to be problematic and would have preferred to enter text by writing on the screen. The Palm PDA used in this study was therefore viewed more favourably than the Psion. Similarly, another participant (B05) who identified himself as “not a touch-typist” felt that he was happy to use the Graffiti handwriting system on his Handspring PDA. He found the Graffiti handwriting to be fast and “very easy.”

Conversely, those who were touch-typists compared handwriting on the PDA unfavourably with typing on a full-sized keyboard:

I mean I can type much faster than I can handwrite anyway. So there's no way that any handwriting entry device is going to be faster than a keyboard entry device. (A11)

And it takes me a long time to handwrite in things because I'm so used to computers. I've always had trouble with handwriting at school. It was a great boon when I left school and didn't need to do written things any more. (B06 - first interview)

For the latter participant, who used a Jornada PDA, the method of entering text using a handwriting recognition system proved to be particularly problematic. He used his PDA primarily to provide portable access to his electronic diary. However, he found

that when in meetings the process of entering text into the PDA was so slow that he was unable to keep up with colleagues. He therefore would scribble the appointment on a piece of paper and type it into the computer when back at the office. During the follow-up interview two years later he said that he was still using his PDA extensively as a time management tool, but his way of coping with the limited text input methods had changed: “[Now I] just block it out and put a couple of letters for what it actually is and then when I get back to my desk I can fill it in properly on the proper keyboard” (B06 - final interview).

He also used a foldout keyboard with the PDA. However, concerns over social etiquette stopped him from making full use of this:

It seems a bit much in a meeting to sort of whip out this folding keyboard. It socially doesn't seem the done thing. I suppose if I wasn't quite so sensitive to what other people thought I might, but I tend not to in meetings. Unless - if it's a meeting with more techy people who've also got their PDAs out and it's all stuff like that then I will. (B06 - final interview)

This can be contrasted with the experience of another participant (B09) who used her foldout keyboard extensively in many situations, including to take notes in small group seminars. When discussing this use of the PDA she dismissed an inherent concern that this method might be disruptive: “I type well. I'm not worried about using the keyboard. I use it very quietly and very lightly and I can almost type verbatim from what people are saying sometimes. I feel that's really useful” (B09 – final interview). This comment was made in the middle of a long response to the question *how do you use the PDA?* Thus, the comment was unsolicited; I did not explicitly ask this participant how she felt about using the keyboard and whether she was worried about using it in seminars.

It seems, therefore, that not only did participants' past experience with other tools have an effect on the way they used the PDA, their different understandings of social conventions also played a part. Furthermore, people differed in their inclination towards using the PDA. Those who were more strongly inclined towards using the device, as in the case of B09, may have been less concerned about drawing attention to themselves when using the PDA. Differences in personal inclination towards using the PDA – defined here as intrinsic motivation or general disposition towards using new technologies – also appeared to have an effect on the time participants were able set aside to learn to use the new device, as described below.

Time and inclination to use the PDA

In Case Study A, many participants felt they did not have sufficient time to learn to use the PDA and integrate it into the activity of reading course materials. The PDAs were given to students during the final block of the course (the “reading block”) when students were also busy doing course assignments and preparing for the final examinable component. Therefore, many students felt they were unable to prioritise the time needed to learn to use the new device and integrate it into their study practices:

It came at a highly pressured time and trying to learn to do the Palm as well as do the studying when you've got your examinable component hanging over your head, was quite a lot to think of. (A08)

If I started a course with it and said 'right, I'm going to build this into my studying' and had time to develop ways of studying, I think it could be useful. [...] The main thing for me is that it's a new tool so I think what I wasn't prepared for was how much I'd have to rethink my study strategies. I think that's the thing. It's more than just a different way of doing things, it actually alters the way you approach your studying. (A10)

That is, there was a contradiction between the activity of integrating the PDA into study practices – and therefore modifying those study practices – and the other course activities that were taking place at the same time. In other words, there were overlapping activities and these interfered with one another. In particular, learning to use the PDA interfered with the *rules* of the course. Students needed to prioritise their time and co-ordinate their involvement in multiple activities; the rules regarding assignment due dates and the course examinable component meant that these activities took precedence over the activity of learning to use the PDA and appropriating it as a study tool. Furthermore, a level of personal motivation to learn to use the device was necessary for students to successfully appropriate the new tool: “If I’d wanted to use it I would have persevered and I would have mastered it ... There is a learning curve but it is not insurmountable” (A01).

In order to gauge some understanding of this personal motivation, I asked students who took part in the follow-up interviews about their general attitudes towards new technologies. Many said that they were particularly receptive towards developments in computing technologies: they liked “gadgets” and enjoyed using new tools. However, they countered that this enthusiasm was reserved for technologies that were useful as learning or workplace tools, and they were not so eager to adopt other new devices, such as home entertainment “toys”: “I like the toys that do stuff. I’m not interested in toys for games or whatever. We had a home PC quite early but we’ve never had a Playstation” (A12).

In contrast, the one student who took part in the follow-up interviews who did **not** use a PDA said: “I just don’t want the annoyance of having to re-learn different ways of working. [...] I’m probably too lazy to learn a new medium” (A16). That is, he did not have the motivation necessary to learn to use the PDA and to adapt his work or study practices in order to successfully incorporate the new tool into these activities. Furthermore, he said that he was quite happy with the tools he already used to support his learning activities, such as a desktop computer and paper artefacts. He did not feel that the PDA offered him any benefits over these existing tools. He was also, as shown in Table 5-1, deterred by the constraints of the PDA, such as its small screen size.

Similarly, participants in Case Study B differed in their personal motivation to learn to use the PDA, as the following comments from the second set of interviews attest:

I’m a user and if something suits me I adapt to using it. (B10)

I was sufficiently interested in Graffiti and I am sufficiently interested intellectually, if you like, in things like voice recognition, and other tools, so I try them out... I’m intrinsically interested in any piece of technology that allows anybody to communicate. I would even say to the point of obsession. So if somebody gives me a tool, I’ll break it. (B02)

There’s always something else, potentially, taking time . . . So if someone had given me a week and said, you’ve got nothing to do, no books to read, and put me in a prison cell. All you’ve got is this PDA and a manual and [IT support] coming to talk to you. Then no doubt life would be different and I’d probably be happy with the PDA now. (B01)

For B01, adapting to using the PDA had a lower priority than other activities, and he did not see any value in pursuing its objective: “the benefits didn’t outweigh the costs, either the costs of getting to know how it worked in the first place or the cost

of continuing to use it while I got the hang of it” (B01 – first interview). Thus, each participant had a different relationship with the object of the activity. For some, the motivation to use the PDA and integrate it into their work or learning activities was strong enough for them to persevere through the initial learning process. For others, the benefits of using the PDA were not so apparent and so the costs involved in learning to use it were more salient, deterring participants from using the PDA.

Personal work and study practices

Participants also differed in their general working practices. For example, in the follow-up interview, B09 said that she had always been a very organised person and this affected the way she used the PDA, particularly its diary function. Previously, when using a paper diary, she had been “very, very particular” about it and made sure it adequately supported her work activities. She adopted a similar approach to using the PDA, keeping the diary up-to-date and ensuring it was frequently synchronised. Similarly, B10 described how she had previously used a diary as both a time and information management system, keeping printouts of appointment schedules, agendas and email messages in her paper filofax folder. The PDA fitted neatly into this preferred way of working. Instead of keeping printouts, which were awkward and messy to maintain, the PDA enabled her to keep electronic copies of meeting notes and agendas, which could be attached to her appointment schedule. She did not have to modify her preferred way of working, but the PDA provided a more efficient means of achieving this.

Similarly, those students in Case Study A who were more receptive towards using the PDA as a reading tool found that it fitted in well with their existing reading strategies. For instance, one participant (A03) said that she would not normally take

notes while reading paper documents, so the fact that this was more difficult on the PDA was not a strong deterrent for her, although she would have preferred to be able to highlight in colour. Another student (A09) told how she would normally type notes into a computer when reading and had previously found it difficult to balance the reading material on her knee while sitting at the computer. Being able to read and take notes on the PDA resolved this problem. Other students, however, preferred working with paper. They liked being able to flick through the document, scribble on the text, write in the margins, and draw diagrams, none of which was possible on the PDA. These constraints will be discussed further in the next chapter.

5.3.2. Tools

In this section I will describe the technologies that participants used in conjunction with the PDA, rather than the tools that helped participants learn how to use the PDA (such as knowledge elicited from other people, which will be discussed further below). A recurrent theme in the interviews was that the PDA was not a stand-alone tool. It was used alongside other technologies, and as such the process of appropriating the PDA involved integrating the new device with the tools that were already used. In order for the PDA to be successfully adopted and used, it was important that it complemented, rather than conflicted with, existing tools. Participants in both studies used the PDA as an adjunct to their main computers. The PDA provided a way of accessing or creating information in digital format, that previously could only be dealt with on a desktop or laptop computer. The new tool, then, made it possible to access this information in situations where a computer would not typically be available, thus extending the capabilities of existing tools: “Because I mean you can’t just pick the computer up” (A04 - second interview).

In Case Study A the PDA did not replace the printed course materials but was used in situations where the A4 folder was inconvenient: “I read the course materials in a wider variety of situations than I would otherwise have done or than I did earlier in the course. For instance, I took it to [the] beach, read it there, which I wouldn’t with a great big folder” (A09). Some students felt that it was valuable to have the option to use either medium. For example, one questionnaire respondent said that being able to read the course materials in both formats was beneficial to this learning activity:

Even though I’ve expressed a preference for reading course notes on paper, this was not a strong preference. I think the PDA had lots of benefits - the key ones being that it was versatile and convenient to use. Having the choice - between paper and Palm - meant that I felt like I could process more of the course material, and consolidate my understanding of it; reading in one domain reinforced reading in the other domain. (questionnaire response)

The PDA appeared to be most valuable to those students who felt that there was a place for the new tool within the existing tools that they used. One interviewee who was particularly enthusiastic about the PDA as a reading tool found that it filled a niche for her because she did not have a computer at home, and suggested that her use of the device may not have been so extensive had this not been the case: “I often wondered when I was using it, if I’d had a computer at home would I have tended towards using the computer a bit more, you know, because the screen is larger and it might be easier to read” (A05).

Similarly, another interviewee (A02) – who did not use the PDA at all – said that one of the reasons he chose not to adopt the new tool was that he felt it did not present any functionality above what could already be achieved with existing tools: “a PDA

didn't offer me anything that I didn't already have in another form somewhere else.” Furthermore, he did not feel that the portability of the device offered any benefits to serve his lifestyle: “If in terms of lifestyle I spent a lot of my time on trains or planes I might use it much more, whereas in reality I sort of have a nine to five job and cycle to work so it's just the PC” (A02). In his situation, then, the existing tools were sufficient for carrying out his study activities.

In Case Study B, too, the PDA was not a stand-alone tool; it was used in conjunction with a more extensive computer tool, such as a desktop computer (see Figure 5-7). As one participant said, “I see the PDA as taking bits of my computer with me when I go” (B02 – first interview). The PDAs used in this study proved to be highly compatible with Windows-based desktop (or laptop) computers (PCs). One participant (B08) said that she was a recent PC user, having always used Macintosh computers in the past. She felt that using the PDA with a Macintosh would have been much more difficult because the two devices had dissimilar interfaces. Another participant (B04) found it problematic to synchronise the PDA with both a desktop PC and a Macintosh laptop (“trying to get these three devices to talk to one another proved difficult”). Furthermore, the PDA and the laptop served similar functions, so there was conflict between the two: “there always was this competition between the PDA and the laptop” (B04). It appears, then, that in order for the PDA to be successfully appropriated as a learning or workplace tool it needed to fill a niche in the activity.



Figure 5-7. A typical desk in Case Study B

The PDA sits on the synchronisation cradle, which is attached to the desktop computer via a cable. Paper artefacts and notebooks also occupy the desk.

5.3.3. Community

In both studies, participants made use of knowledge elicited from the communities in which they belonged. Students who took part in the follow-up interviews in Case Study A were asked about their workplace context: how new technologies were perceived and used in their workplace, whether their colleagues also used PDAs or similar devices, and whether their employers provided IT support for these tools. The one non-user in the interview sample said that he believed that staff members who used PDAs were viewed as “posers” in his workplace and that the devices were therefore seen in a negative light by his colleagues. He described a team planning meeting in which another member of staff was using a PDA, which appeared to be more time-consuming than using more traditional tools: “we had to stop and sit

around for half a minute every so often while this person tapped in her commitment while the rest of us used a bit of paper and made a tick or crossed it off and were ready to move on” (A16).

In contrast, another student (A14) described how her employers had recently begun supplying management staff with Palm PDAs, and therefore providing technical support for their use in the workplace. Hence, many of her colleagues were using PDAs as workplace tools, and, seeing their value in this context, she decided to follow suit. She found that they were particularly valuable in meetings: if all attendees had a PDA – and therefore a means of accessing their electronic diaries – it became much easier to arrange follow on meetings than it had previously been. The PDA, then, came to be a valuable time management tool in this context.

Similarly, in Case Study B, members of the workplace community, as well as the wider community of friends and family to which participants belonged, were an important source of knowledge about how the new tools could be used and integrated into workplace activities. Knowledge elicited from the community was also useful for providing trouble-shooting strategies when technical difficulties arose. Several participants acknowledged the support of IT staff in the workplace who helped overcome technical difficulties and provided support for the process of setting up the device and ensuring it was successfully integrated with other workplace tools, such as the desktop computer.

One participant (B10) spoke of the help she received from a friend while away from the office when she experienced a problem with the screen contrast on the PDA.

This problem could be easily resolved with access to the appropriate knowledge. However, in this case the problem occurred while the user was away from the office and therefore did not have access to either a manual or workplace IT support. Instead, a friend who also used a PDA was able to alert her to the solution.

Another participant described how his informal conversations with technical support staff made it easier to cope with technical difficulties and to explore new uses for the PDA:

JW: Have you called on technical support at all?

B06: I don't think I have. I mean I've talked to [technical staff] but the line between what's just social chatter, what we happen to talk about over lunch, and what's formal technical support, is kind of hard to draw. But I suppose that's what makes it easier for me to play about with it because I've got lots of people who I talk to regularly so if I feel that I'm stuck with something I could talk to them about it without feeling like I'm making a formal IT support request. (final interview)

Furthermore, some participants spoke of how they had witnessed other members of the community using different PDAs. This served to highlight benefits and limitations of the devices colleagues were using, and also provided information about how PDAs could be further exploited to support workplace activities. For example, two participants attended meetings outside the UK in which other attendees used PDAs to beam information to one another or to access wireless networks. Another participant spoke of how she had learnt what to expect from her PDA because a colleague had previously bought one:

Before I did the project the person that I shared an office with bought one last Christmas so I feel as if I've lived through what they do, what they don't do, the miseries of lack of synching and all of these sorts of things. (B09)

Community knowledge also played a part in one participant's (B01) decision not to integrate the PDA into his workplace activities. He saw that other people found the data input methods irritating and this confirmed his belief that the tool would be difficult to use. In addition, he read articles in the press that also highlighted limitations of the device. This information contributed to his decision not to persevere with using the PDA.

Participants also had access to community knowledge through the online discussions that were used in each study. For example, students in Case Study A were able to use the FirstClass conferencing facility to exchange information about how they had used the PDA, what problems they had encountered, advice about overcoming technical difficulties, and suggestions about new software or features to try. Of course, this knowledge-sharing facility would not typically be available in other contexts when a new tool is introduced. However, it was apparent in these studies that the FirstClass conference and email discussions were valuable facilities for participants to share information, as well as providing a means of further data collection for the purposes of the research.

5.3.4. Rules and division of labour

In Case Study B, departmental rules and informal regulations were called upon when participants encountered technical problems with the PDA. It was standard practice to ask for help from the department technical support team when such problems occurred. The task of resolving technical problems was then divided among members of the IT support team, the PDA user, and other members of the community who were able to contribute appropriate expertise.

In some instances, it became apparent that there was a quaternary contradiction between the activity of integrating the PDA into workplace practices and the co-existing activity of providing departmental IT support. As described in Chapter 3, a quaternary contradiction is a contradiction between two co-existing activities (Engestrom, 1987). In this instance, the activities of providing IT support and integrating the PDA into workplace practices were co-existing: they took place within the same social context and when device breakdowns occurred, the activity of PDA appropriation became dependent upon the activity of IT support provision. A contradiction occurred because the IT support activity had its own set of rules (i.e., priorities for providing support to various projects and staff members), division of labour (the availability of support staff to help resolve problems), and objectives (to provide technical support across the entire department). These were different from the rules, division of labour and objectives of the PDA activity – that is, to integrate the PDA effectively into work practices. Consequently, there was a contradiction between the two activities. This contradiction had the effect of disrupting the tool appropriation activity, making it difficult at times for participants to overcome technical difficulties and continue using the PDA to the extent that they wished.

A similar contradiction became apparent when two participants needed to have their PDAs replaced. For one participant (B03), this occurred because her PDA (a Handspring) had been destroyed in an accident. (Actually, it had been chewed up by the dog!) The Handspring was replaced with a Hewlett Packard Jornada, which has a Microsoft operating system and a somewhat different interface to the Handspring. Therefore, using this new device would have required further learning and

adjustment on the part of the user. However, this did not eventuate. The PDAs used in this study belonged to IET and, although participants had complete ownership over the devices in most respects, if they no longer wished to use it or if they changed jobs, they were expected to return the device to the “loan pool,” a collection of technologies owned by the department and loaned out to staff members. The Jornada PDA that was given to B03 had already been used by another staff member (not a participant in this study) and returned to the loan pool. Consequently, some of the original contents of the box in which it arrived were missing, including the CD with the software to be installed on the desktop computer. Despite spending much time trying to locate this disk, the participant was unable to find it and therefore did not proceed with using the new PDA.

A similar problem occurred for another participant (B10) who had her PDA replaced after two years when the screen sensitivity was lost. The replacement PDA had previously been used by another staff member and some contents were also missing from its box, including the instruction manual and the installation disk. This raises questions about the operation of the loan pool in IET, suggesting some contradictions in the activity system. There is an assumption (rule) that all technologies included in the loan pool be lent out to people in full working condition, but no one person (division of labour) is responsible for checking the devices and ensuring that all the contents needed for the device to work are there. Furthermore, it may be that the portability of PDAs increases the likelihood that peripheral parts will go missing, suggesting that they may not be appropriate technologies to be included in a loan pool. It appears, then, that there were contradictions between the object of the tool

appropriation activity (the PDA) and the rules of the loan pool activity system, leading to conflicts when the two activity systems coincided.

5.3.5. The object - the PDA

In Case Study A, the PDA had certain characteristics that did not lend itself to being utilised as a reading tool – principally, as discussed further in the next chapter, the small screen size. For example, although Jane (A09) had been enthusiastic about the PDA and did initially use it as a reading tool, she was ultimately unable to persevere with this due to eyestrain problems. She suffered visual disturbances and migraines when attempting to read from the small screen of the Palm m105, but found these problems were not so pronounced when using her own Psion Revo, which had a larger screen. This is an extreme example of how the characteristics of the device might prevent it from being used in the way it was intended. In this case, the user was keen to integrate the new tool into her learning activities but was unable to do so due to a combination of the device limitations and the physical constraints she encountered. This raises the question of whether PDAs are accessible as reading tools for people who experience visual difficulties. Certainly, worry about eyestrain was an issue raised by other participants in the post-questionnaire responses, and so appears to be a limiting factor in how successfully the PDA can be used as a reading tool. Although participants could change the display size of the text, this reduced the amount of text that was visible on the screen; some students suggested that this further reduced the usability of the tool.

Furthermore, in both case studies technical problems – or device breakdowns – did occur, although these were mostly overcome. Battery life was a common concern. In particular, this was a problem in Case Study B for those using Handspring Visors,

which operated on disposable batteries, and those using the Hewlett Packard Jornada, which had a rechargeable battery with a very limited battery life (approximately seven hours). This meant users had to carry the battery recharger with the device if they were going to be away from the office for more than a day, thus limiting its portability. One participant (B08) went to the United States for two weeks and was unable to recharge the battery; the device consequently lost all its data (a problem that could be subsequently resolved by synchronising the PDA with the main computer).

Another participant (B02), who was using a Handspring Visor, found the constant need to change batteries to be such a limitation that he stopped using the device, despite having used it extensively for the first six months of the study. In an email, he gave the following description of the problem:

I decided over the New Year that I was going to give up my PDA. I've been using a Handspring Visor since the project started. I have certainly found it useful, particularly for diary and in my case (in the absence of a laptop) for editing documents with the unfolding keyboard on trains or late at night when the home machine is otherwise occupied.

And that's the problem - any significant use of the PDA, even with all the power settings set to minimum, eats batteries like there's no tomorrow. I seem to change batteries almost fortnightly. In the absence of a recharging synch cradle I simply have found this not to be viable way of working. (B02 - email)

During the second interview, this participant clarified that he had actually continued using the PDA but for fewer functions so that the battery life could be restored:

I originally used it quite heavily - maybe because it was a new piece of technology or maybe because I felt that it would be very useful . . . I then began to lose patience with it and stopped using it for about a month. And

during that month I found out why it was actually important to me and began using it again. But my usage before the sabbatical [from the PDA] and after the sabbatical have changed somewhat. So before I stopped using it I really was doing a bit of everything. I was experimenting with delivering stuff onto web pages and synchronising them and using it for word processing and using it for notes and beaming things to colleagues and getting extremely carried away. Since [then] it has become a diary. I don't really use it as a working tool, I don't edit word documents on it, I've stopped using the attachable keyboard. I just carry it around as a Hot-synched diary. (B02 – second interview)

The relationship, therefore, between the subject (B02) and the object (the PDA) had been changed through the constraints of the PDA. This had the effect of modifying the activity: the PDA could no longer be used to support the variety of work practices for which B02 had originally used it. Interestingly, despite this, B02 continued to use the PDA throughout the study; after changing jobs and moving to another institution (whereupon he returned the PDA to IET's loan pool), he bought his own PDA so that he could continue to have a portable electronic diary that could be synchronised with his Outlook calendar.

5.3.6. Outcome: dependence on the new tool

One outcome of the successful adoption of the new tool was an increased dependence on the PDA. The portability of the PDA made it a highly personal tool. For some participants, it became an essential handbag or shirt pocket item: "it goes in my handbag with all those other crucially important things like my credit card, my reading glasses, my car keys ... Those are what I need to function" (B10).

Those who used the device extensively came to rely upon the tool ("my Palm is now my friend" – A14). This was particularly the case for those who used the PDA as an organisational tool. For instance, in Case Study A, Jane (A09) submitted this

message to the FirstClass conference in response to another student's query about borrowing someone's PDA:

For me, lending someone my Psion would be akin to lending someone my personal diary. I not only store all birthdays (with alarms to remind me) all my appointments, kids functions etc, but also personal and household finances in the spreadsheet area, a full list of names, addresses and phone numbers of everyone I know, all my security codes, all other important numbers - serial numbers, national health numbers, card numbers and emergency phone contacts. Absolutely anything and everything I need to know is in the one place. It goes everywhere with me. ... I could not conceive of letting anyone else look at it, let alone borrow it. (A09 - FirstClass contribution)

Similarly, for participants in Case Study B who felt they would be lost without the PDA, technical breakdowns were catastrophic. One participant (B08), who lost data when her PDA battery went flat, likened it to feeling "let down": "it's so significant when you start to really like it and you depend on it and it lets you down once, once is too often" (first interview). Another participant who had experienced a technical breakdown which was then recovered without the loss of data, described how she then became extra cautious about information stored on the PDA:

because you've begun to use it nearly every day and there's an awful lot tied up in it . . . you do a lot of double-checking. It's not as dramatic as if you had been burgled, say, and you're always checking or wondering. It's not on that level but it is in terms of your work. It does worry you, that you might have lost information that you might not have kept in some other form. (B09 – first interview)

While this dependence on the PDA was apparent in those who fully adopted it and integrated it into their workplace activities, it was clearly absent for B01, who did not use the PDA. He was disappointed that the PDA did not become a "life-serving instrument." He said the PDA was not an essential tool in the way his desktop

computer was. It appears, then, that users expect to become dependent upon the tools they use. The PDA is a highly personal tool. It can be used to store personal information or information that is essential for carrying out personal organisational activities such as time management. Therefore, it is not surprising that dependence upon the PDA – or some level of emotional attachment – was one outcome of the new tool being fully integrated into learning and workplace activities.

5.3.7. Summary

This section has described an analysis of tool appropriation in Case Studies A and B. The analysis was based on the ASTAM framework presented in Figure 5-6. This framework helped to highlight the sociocultural factors that appeared to influence the way participants in each study appropriated the PDA.

Each participant brought to the activity his or her own unique combination of past experience with other technologies, personal inclination towards using new technologies, and personal preferences for different work and study practices. These each appeared to have an effect on how participants used the PDA.

The analysis also showed that the “tools” component involved both the tools necessary to learn to use the PDA and the existing tools that participants already used. An important part of the tool appropriation activity was the integration of the new tool into a suite of existing technologies. This appeared to be particularly important for the PDA which was used in conjunction with other technologies. In the case studies described here, each participant took part in a unique web of activities, involving a variety of other mediating tools. It was important, therefore, for the PDA to complement, rather than conflict with, those other tools.

Furthermore, each participant was part of a different community of students, colleagues, family and friends, who also contributed to the tool appropriation activity. Participants relied upon information elicited from members of the community to overcome technical difficulties, develop new uses for the device, and as a basis of comparison for evaluating their own use of the PDA. In this way, members of the community contributed to “narratives of use” about how the PDAs could and should be used (Churchill & Wakeford, 2002).

The community also contributed to the tool appropriation activity through the rules and division of labour that mediated the activity. As shown in Section 5.3.4, when a new tool is introduced in a workplace context some of the rules of that workplace will be relevant to the tool appropriation activity. For instance, rules governing the division of responsibilities for technical support will be important if technical difficulties are encountered. Furthermore, there may be regulations, or expectations, governing how the new tool should be used. For instance, the initial purpose of Case Study A was to examine the use of PDAs as tools for reading course materials. Students therefore approached the activity with the expectation that they would use the PDA as a reading tool. When they found it difficult to utilise the device for this purpose some students felt the device had failed, despite the fact that many did use it extensively to support other activities. This was also apparent in Case Study C, as shall be discussed in Chapter 7, in which senior staff at a large organisation were supplied with PDAs to provide them with portable access to the company Intranet. Because the tools were not used for this purpose – despite being used to support

other activities – there was a common belief among the technology providers that the PDAs had failed and that employees were not getting best value out of them.

The object in the ASTAM framework is the new tool that is being appropriated. In this case, this refers to the PDA. As both case studies demonstrated, different features of the PDA influenced the appropriation process. For instance, the small screen size made it difficult for some participants to use the PDA, while battery life limitations were also a deterrent. Participants were also concerned about technical difficulties – resulting in a fear that information stored on the PDA might be lost.

The model in Figure 5-6 shows two potential outcomes of the tool appropriation activity – integrating the new tool into other activities, and a feeling of dependence on the new tool. It could be said that the latter outcome is a consequence of the first. In both case studies presented in this chapter, many participants who had successfully integrated the PDA into their activities appeared to have an anthropomorphic view of the PDA; the PDA was considered to be a friend or companion. This can be likened to Christiansen's (1996) argument that when a new tool is integrated into the user's activities, the user will learn to "care for it, nurse, and cultivate it" (p. 175). This may be particularly the case for a tool such as a PDA which can go everywhere with its owner in a shirt pocket or handbag. Whether this aspect of tool appropriation is common to all technologies, however, remains to be seen.

5.4. CONCLUSION

In this chapter I have analysed the process of tool appropriation as it occurred in Case Studies A and B. The analysis was guided by concepts from activity theory. Tool appropriation was analysed as an activity system in itself, using the ASTAM framework. This proved to be a useful way of identifying and categorising the sociocultural factors that contributed to the process of tool appropriation. Each of the components in the activity system contributed to an explanation of why the PDAs were used in such disparate ways by participants in both studies.

The two studies were analysed together in this chapter because they both presented similar findings regarding the concept of tool appropriation. Similarly, both studies revealed comparable data describing how the PDA mediated the learning and workplace activities it was used to support. The analysis of tool mediation in Case Studies A and B will be described in the following chapter.

Chapter 6

How the PDA Mediated Learning and Workplace Activities in Case Studies A & B

This chapter addresses the second research question of the thesis: how do PDAs mediate learning and workplace activities? Data from Case Studies A and B were examined to assess how the possibilities and constraints introduced by the PDA had an effect on the activities of (a) reading for learning purposes, (b) workplace time management, and (c) workplace information management. The analysis showed that the benefits and limitations of the PDA – such as its portability, compatibility with other technologies, small screen size, and awkward text input methods – changed some of the actions and operations that contributed to each activity, and had a modifying effect on the overall activity systems.

This chapter begins by looking at how the PDA mediated the reading activity in Case Study A. This will be followed by an analysis of how the PDA changed the activities of workplace time and information management in Case Study B. The analyses presented in this chapter will then be used to develop a model that describes how new tools change the activities they are used to support. This model has been labelled the *Tool Integration Process* (TIP) model, and is described in Section 6.4.

6.1. THE IMPACT OF THE PDA ON READING

In this section, I present an analysis of data from Case Study A, using concepts from activity theory to describe how the possibilities and constraints introduced by the PDA had an effect on the activity of reading for learning purposes. The purpose of Case Study A was to evaluate the use of PDAs as tools for reading course materials. As described in Chapter 4, all 65 students on an Open University course were supplied with Palm m105 PDAs, along with document viewing software and the electronic version of three sections of the course Study Guide. Students were then able to use the PDA to read those sections of the Study Guide, although they also had access to the printed version of the course materials. Therefore, in the interviews and questionnaires, students made many comparisons between reading from paper and reading from the PDA, thus contributing much data about how tools mediated the reading activity.

The following analysis begins with an overview of students' assessment of the benefits and limitations of using the PDA to read course materials, with Sections 6.1.3 to 6.1.5 providing a more in-depth analysis of how these benefits and limitations affected the reading activity in terms of (a) the portability of the PDA, (b) the impact the PDA had on navigating and scanning through the text, and (c) the impact the PDA had on note-taking and highlighting strategies. Before presenting this analysis, however, the following section describes the strategies and tools involved in the activity of reading for learning purposes, incorporating a brief review of some past research that has examined the use of paper and computer technologies as reading tools.

6.1.1. The reading activity

Reading is a widely accepted learning activity. It is an integral part of school and university education, and the use of written text continues to be one of the foremost means of communicating and sharing information in our society (Sellen & Harper, 2002). However, with the recent increase in the use of digital resources such as the Internet, and the availability of e-book reading software for PDAs and other portable devices, the activity of reading is no longer confined to the use of paper documents. Using a computer as a medium for reading text can offer advantages such as efficient search strategies, hyperlinks that connect sections of text, and convenient storage of large amounts of information (Dillon, 1994; Want & Borriello, 2000). However, people generally prefer reading paper documents to reading text on a computer screen (Dillon, 1994; O'Hara & Sellen, 1997; Schilit et al., 1999). One of the reasons for this is that people interact with paper in ways that are often not possible with electronic text. For instance, research has shown that when reading for learning purposes, people write notes in margins, annotate and highlight text, flick back and forth within documents, and write separate summaries of the text (Marshall et al., 2001; O'Hara et al., 1998).

In other words, the actions that people undertake when reading are closely entwined with the tools that have traditionally been used to support reading, such as pen and paper. This can be illustrated by a study carried out by O'Hara and Sellen (1997), who compared reading on paper with reading on computers and found that paper offered several advantages over computers. Participants in their study were assigned to either an "online" condition or a "paper" condition, and were given a 4-page article to read and summarise. Those in the paper condition were able to navigate

efficiently through the document, using their familiarity with the page layout to flick through the pages, simultaneously recording notes on separate paper. In other words, these processes were operationalised. Meanwhile, those using the electronic version found it cumbersome to switch between viewing the document and taking notes (which was also done on the computer), and they were only able to perform these actions serially, rather than simultaneously. Thus, using the new tool constrained the activity of reading by introducing new conditions for the activity, which made it difficult for participants to utilise the operations they had developed from past experience with paper documents.

It is to be expected, therefore, that a new tool such as a PDA would create new conditions for the reading activity which may inhibit the use of operations previously developed and require new time-intensive actions. The analysis presented below aimed to identify such changes, as well as to examine the impact of the PDA on the wider social context of the reading activity in Case Study A. This analysis is based on students' accounts of the strategies they used when reading for learning purposes, and their beliefs about how the PDA had an effect on those reading strategies. This was a topic of much discussion in the first set of interviews (carried out at the end of the course, two months after students were given the PDAs), and was also the subject of several post-questionnaire items. Therefore, unless otherwise specified, the interview extracts included in the following discussion are taken from the first set of interviews, while comments attributed to questionnaire responses are taken from written answers to the open-ended post-questionnaire items.

6.1.2. An overview of the use of PDAs for reading course materials

Of the 35 students who responded to the post-questionnaire in Case Study A, 26 (74%) said they had actually made use of the PDA to read course materials. The post-questionnaire also asked students to rate, on a five-point scale, how easy or difficult it was to read course materials on the PDA. Figure 6-1 shows students' responses to this question. As illustrated, most students found it *somewhat difficult* or *very difficult* to read text on the PDA. Students were asked, in an open question, to indicate why they felt it was easy or difficult to read course materials on the PDA. Reasons given included difficulties reading small text on a small screen, the awkwardness of having to scroll through the text, difficulties skim-reading and navigating through the text, and the inability to annotate and highlight text. In contrast, the small number of students who found it easy to read text on the PDA said that being able to read the course materials unobtrusively in various locations was an advantage and made it easier to fit reading around other activities. These issues are elaborated further below.

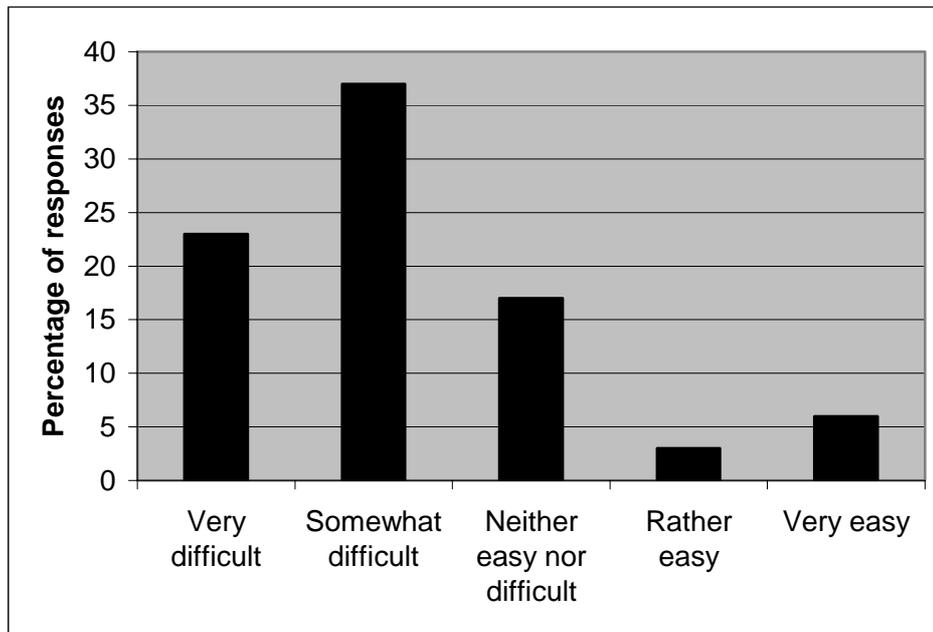


Figure 6-1. Students' assessment of how easy it was to read course materials on the PDA *

* (N=35). However, 5 respondents did not answer this question

6.1.3. Portability of the PDA

Unsurprisingly, students identified portability as the main benefit of using the PDA to read course materials, providing anytime, anywhere access to the sections of the Study Guide it contained. As one questionnaire respondent said, the PDA was an “unobtrusive and neat device that could always be to hand.” For some students, the portability of the PDA offered benefits over the printed version of the materials, although these were also, strictly speaking, portable. The printed Study Guide was supplied as loose A4 paper collected together in a ring-bound folder. Therefore, sections of the Study Guide could be removed when students wanted to use them while away from their usual study environment. However, some students found this solution to be awkward compared to the small, lightweight PDA:

I like the flexibility that the PalmPilot gave me. Because I could take that anywhere. The only problem with the paper version, with A4, you have to take it out of its binder if you want to transport only just one section. Otherwise you've got this huge binder to carry around with you. (A04)

It made it [reading] a bit more flexible for me, really. That was the biggest thing, I think, that I could carry them around with me, that I wasn't looking after lots of different sheets of paper, that it was all there together. (A05)

One student (A03) said that she felt she needed to “sit down and concentrate” when reading the printed Study Guide (as opposed to reading the documents on the PDA). Another (A05) said that reading printed documents was “a bit more of an ordeal sometimes” than reading from the PDA. The properties of the PDA, then, made it more conducive to studying anytime, anywhere. This also overcame a limitation of the desktop computer, which many students used as the main technological tool to support their studies: “I found I could fit studying into the gaps in between other things. Whereas with the computer I had to plan to be near the computer” (A10).

Fitting study “into the gaps” was important for students on this course. A general characteristic of Open University study is that it is flexible: it is typically undertaken part-time and students must fit their studies around other activities such as work and family commitments (Jones, Kirkup, & Kirkwood, 1992). Students on H802 were part-time postgraduate students and many also worked full-time or co-ordinated busy family schedules. It was, therefore, an unwritten rule that “you use every little spare bit of time you can” (A09) in order to successfully complete the course. For those such as Jane (A09 – see Chapter 5, Section 5.1.4), whose spare time consisted of short breaks within other activities, the PDA offered a clear benefit as a study tool:

A09: It was so much easier to do the work, you could do it everywhere and when you're trying to fit it in around work and kids and everything, that was an enormous advantage ...

JW: Would you say that your lifestyle is a sort of mobile lifestyle? Do you travel a lot or is it just that you're in a lot of different places during the day?

A09: Yes, I mean I don't travel by train to go to conferences and things like that, but with the kids I take them here, there, and everywhere and we go away for weekends, it's that sort of thing. So I guess the home part of my life which is where I tend to do a lot of my OU work, is fairly mobile. And I have a lot of odd periods, half an hour here, fifteen minutes there, where I'm waiting for them to come out of somewhere. It's all the little wasted slots of time where a Palm would be great.

For some students, then, there was a contradiction within the activity system of their OU studies. While they felt they had to make use of every fragment of time that became available when carrying out other activities, the existing tools that were used to support their studies – printed reading materials and a desktop computer – were not conducive to this rule. Instead, some students felt they needed to set aside time in order to make use of the mediating tools. In contrast, the PDA provided a means of accessing sections of the course materials wherever, and whenever, there happened to be a spare window for their OU studies.

6.1.4. Moving through the text: navigating and scanning

Despite the positive response to the portability of the PDA and the benefits this offered to the activity of reading course materials, the PDA also changed reading in some less desirable ways. Inevitably, the small screen size of the PDA constrained the reading activity, making it impossible to see more than a few lines of text at a time. Figure 6-2 provides a screen shot of the text on the PDA. As the figure illustrates, only eight lines of text are visible. This small screen display meant students were unable to scan through the text, and felt they were forced to adopt a *line-by-line* reading strategy when reading from the PDA. This made it difficult to

utilise the skim-reading strategies that some students would typically use when reading from paper:

When I read I tend to sort of look at a page and look down the page and skim-read and then go back and read it completely, and then perhaps even in more complicated sections I might go back and read it again. That I found impossible to do. I just found it basically impossible to do anything other than just keep reading through on the Palm. (A07)

Furthermore, the small screen on the PDA had an impact on the ease with which students could navigate through the text, an operation they said they could undertake quite proficiently when using the printed course texts. This was an issue students had anticipated when, in the pre-questionnaire, they were asked why they believed the PDA would or would not be useful as a tool for reading course materials. One respondent said:

I frequently know exactly where to find something I've read and want to return to, because I can picture in my head exactly where it is on the page. I won't be able to do that with scrolling text. The tactile qualities associated with book reading are essential. (pre-questionnaire response)

Similarly, when interviewees were asked how reading from the PDA compared with reading from paper, several students referred to difficulties they experienced when navigating through the text and judging their location within the document on the PDA. The inability to locate the small amount of text on display within the wider context of the document made students feel "lost." It was difficult to pick up on visual clues, such as headings, and some contextual clues, such as page numbers, were not available on the PDA. Therefore, students had to learn to use new contextual clues to aid the process of navigation, and this caused some disruption to the reading activity. In addition, it was difficult, on the PDA, to see the headings in

the document. Although the headings were typically italicised, emboldened, or in a larger font than the body of the text, they were still more difficult to identify than were the headings on the paper version of the materials. As one questionnaire respondent said, “there was no break in the text. Reading printed materials - the page is set out to show areas, categories, etc. Demarcation was not obvious.”

Therefore, the documents on the PDA may have benefited from more extensive use of formatting in order to emulate printed materials, thereby making it possible for students to utilise the navigational operations they had developed through previous experience of reading from paper.

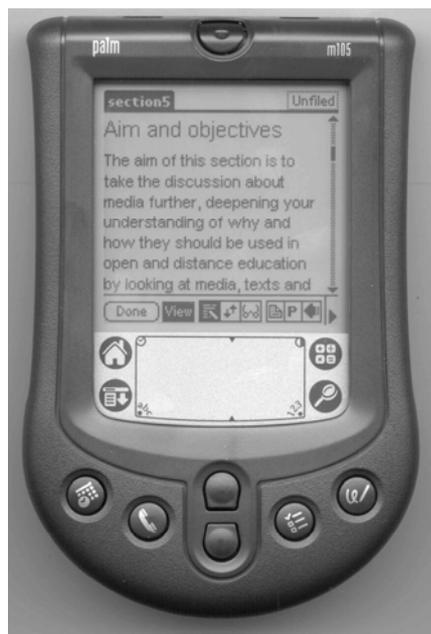


Figure 6-2. Screen shot of H802 Study Guide on PDA

6.1.5. Interacting with the text: note-taking and highlighting strategies

In the post-questionnaire, students were asked about their strategies for marking up text and note-taking when reading course materials on both the printed Study Guide and the PDA. Figures 6-3 and 6-4 illustrate the responses to these questions, showing the percentage of respondents who answered *never*, *sometimes* and *frequently* to each question that asked how often students used these strategies. Both figures show that students were more likely to highlight the text and take notes when using the paper version of the course materials.

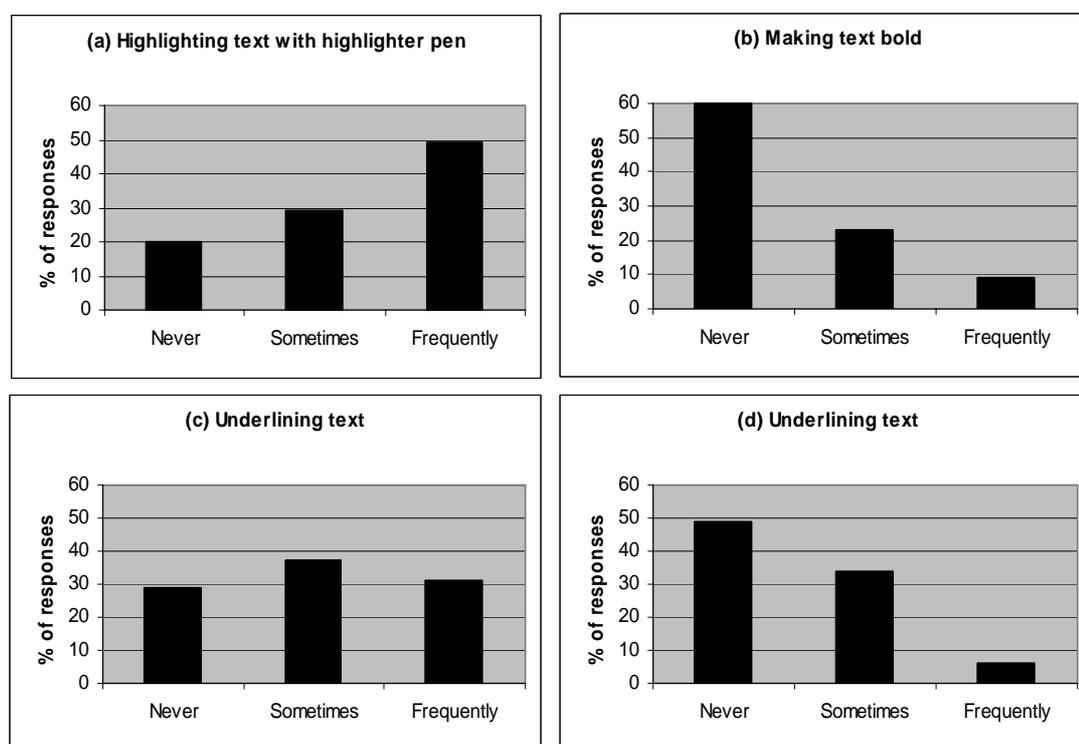


Figure 6-3. Marking up print and PDA course materials

Panels on the left-hand side (a & c) refer to use of the printed Study Guide. Panels on the right (b & d) refer to use of the Study Guide sections on the PDA.

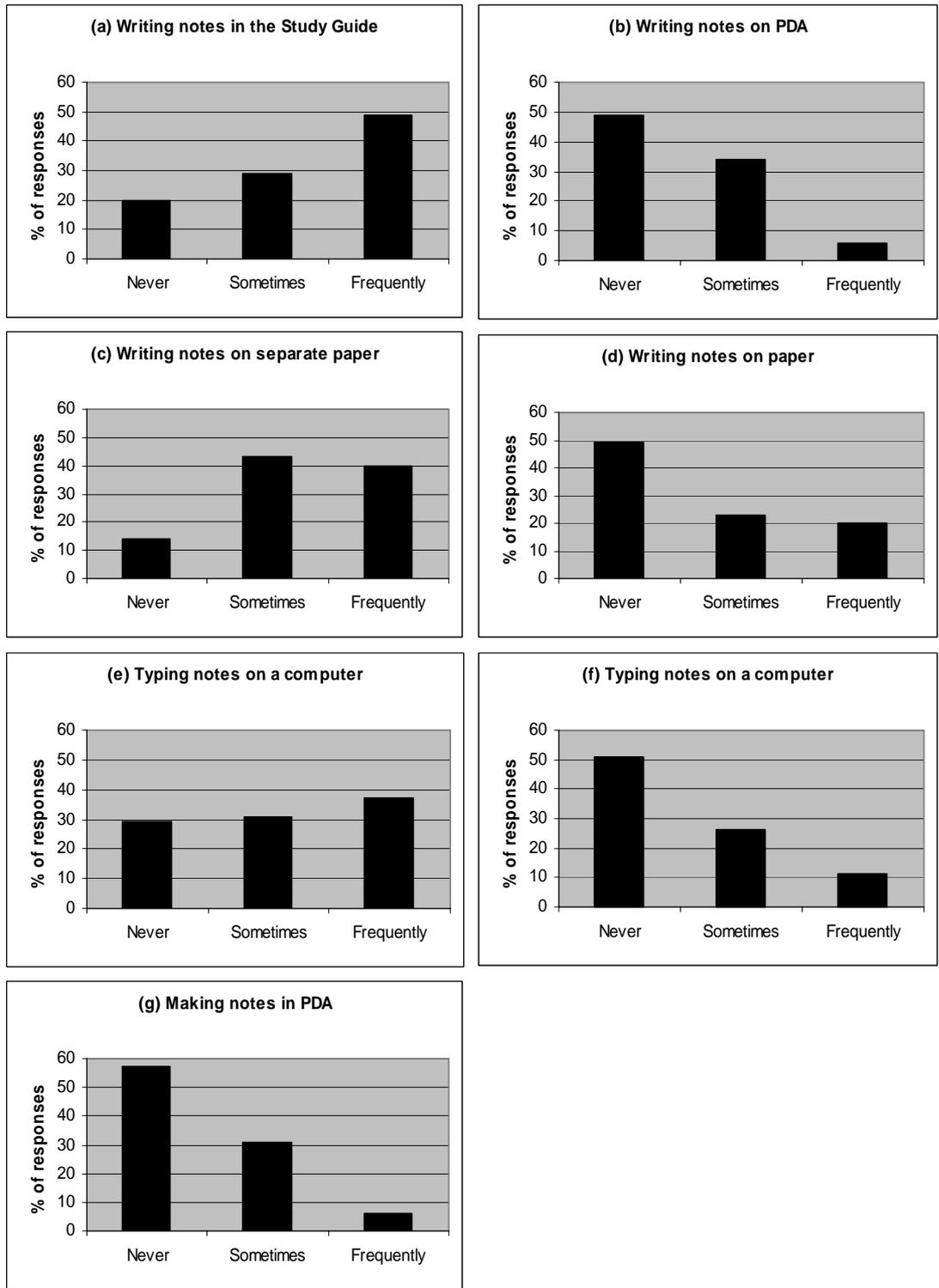


Figure 6-4. Note-taking strategies when using paper and PDA course materials. Panels on the left-hand side (a, c, e, & g) refer to use of the printed Study Guide. Panels on the right (b, d, & f) refer to use of the Study Guide sections on the PDA.

Some of the note-taking and highlighting strategies that students may have adopted when reading from paper were not supported on the PDA. For instance, it was not possible to write notes in the margins or scribble diagrammatic notes on the text. Instead, note-taking while reading on the PDA involved either writing the notes within the Study Guide document, or opening a separate WordSmith file and recording the notes there. This then involved an awkward process of moving between the main document and the notes file.

Similarly, highlighting text on the PDA involved underlining or making it bold. Few students said they did this frequently, whereas nearly 50% of questionnaire respondents frequently highlighted text with a coloured pen when using the printed Study Guide. Some students found it quite limiting to be unable to utilise these strategies for interacting with text on the PDA:

I didn't, in fact, take any notes on the PDA. But then I don't very often take notes when I'm reading text in a file or on paper either. But what I do do is highlight. It would have been very useful to be able to highlight on the PDA as well - bits that I think are important. [...] and it would be good to highlight in different colours, different sections and points that you think are important.
(A03)

I could only do writing, I couldn't do diagrams or anything ... that's my preferred study style. I'm quite visual so I like to draw little arrows between things and show connections. So the PDA didn't exactly lend itself to that.
(A10)

Nevertheless, some students adapted their strategies for interacting with text in order to make use of the properties of the PDA. For instance, these interviewees described how they would copy and paste text from the document in order to summarise the content:

I just made myself a new file in WordSmith and cut and pasted to that, or sometimes I cut and pasted elements of the section that I was reading to the very bottom of the section, so I had some notes printed out at the bottom. (A07)

What I did do with the PDA was summarise the material that was provided. So I could go through and I could cut out bits and I should edit other bits so I could convert the file that was a complete block into one that was just a summary. (A10)

However, both interviewees quoted above found that using the PDA to copy and paste text was inferior to highlighting and taking notes on paper. When asked whether she used the selected sections of text to aid revision, A07 said she did not find it particularly helpful for this purpose, and found it quicker to read back over highlighted text on paper: “I would normally look through my highlights and places where I'd made notes in the margins or something and again you can do it so much more quickly that way – by looking at, you know, A4 size pages – than you could on the PDA” (A07).

Similarly, A10 found that it was much slower to summarise the text on the PDA than it was to select and make notes on sections of text in the printed Study Guide. She therefore abandoned the strategy of cutting and pasting text on the PDA and reverted to using the paper version of the Study Guide:

I spent a few hours doing that summary because I was on trains and bus stops and things like that and after I'd been doing it for several hours I thought 'I wonder how far I've got through the paper?' and I looked at it and realised I'd done all of four pages so then what I did was I went through the rest of the paper bit in about half an hour and did what I wanted to do. So I didn't use the PDA-based stuff because it was just so much more effective to do it on paper. (A10)

That is, for this student it was faster and more convenient to utilise the operationalised processes that she had developed through years of experience using printed reading materials, rather than to make use of the unfamiliar actions that were required when extracting text from the PDA document.

Similarly, many students said they did not like to take notes on the PDA. One reason for this is that they found the text input mechanisms on the PDA to be slow and difficult to use. As described in Chapter 4, the Palm PDAs used in this study had a touch-sensitive screen and a pen-like stylus for data input. Entering text involved either using the Graffiti handwriting system – whereby the user learns to write alphabet characters in a specific way so the PDA will recognise them and convert them into type – or by tapping out letters on a small on-screen keyboard. These methods were generally compared unfavourably to typing on a full-size keyboard or writing on paper. In particular, using the Graffiti handwriting system was slow and error-prone, as illustrated by this interview comment:

I experimented with the writing part . . . and of course one of the problems was the letters weren't always coming out as I intended but I think that would have been a question of practice. So I got to the stage of being able to write and produce letters in print form on the screen but as it took a lot of time to do it I gave up. (A02)

That is, the PDA did not support operationalised processes for writing. Students had to learn how to construct each individual letter in order for it to be recognised by the Graffiti handwriting system. Therefore, writing became a letter-by-letter process, involving a series of attention-demanding actions. While some students suggested that using Graffiti became easier with practice, others felt that the process continued

to be awkward and frustratingly slow: “I did practice for a long time, I just didn’t feel like I got it” (A07).

Similarly, one of the students who took part in a follow-up interview – who had his own Palm-based PDA and therefore had developed some familiarity with the Graffiti handwriting system – also found writing on the PDA to be slow and difficult. He described how he had adapted his use of the device to allow for the text input limitations:

The thing I like least about any Palm is the text entry mechanism. You can get about as far as writing a person's name in the date field in order to record a diary appointment. ... But it doesn't matter if you're just putting in a diary entry but if you're actually trying to write something it's completely useless. So I don't use it for annotating or anything like that but I do carry lots of reading material on it. I read from it and if I want to make a note I just make a note with a pen and a piece of paper. In the traditional manner. (A11)

Other students also adapted the way they took notes in order to make use of the PDA for this purpose. As Figure 6-4 shows, a small number of students persevered with the data input methods on the PDA in order to take notes on the course materials, while more than 30% of questionnaire respondents (13 students) said they *sometimes* or *frequently* took notes on the PDA while reading the printed version of the Study Guide. These students typically developed strategies to overcome the limitations of the PDA. For example, because the PDA notes were in electronic format and could be easily transferred to the desktop computer, errors could be ignored and corrected at a later time: “the key thing was to get the notes down. If the odd character was wrong it was more time-consuming to go back and correct it than it would be just to sort it out when you've got it on the main machine” (A09). The PDA, then, was not an isolated tool, but could be used in conjunction with the desktop or laptop

computer, and this extended its possibilities, making it feasible to use the PDA as a note-taking tool.

The use of the PDA as a note-taking tool is described further with reference to information management in Section 6.3.3. Meanwhile, the following section looks at how the PDA changed the activity of workplace time management in Case Study B.

6.2. THE IMPACT OF THE PDA ON WORKPLACE TIME MANAGEMENT

In this section I examine data from Case Study B, in which the PDA was used primarily as a tool for supporting workplace time management. The purpose of Case Study B was more exploratory than the previous study, the intention being to evaluate the use of PDAs as general workplace tools. As such, PDAs were not given to participants to be used for a specific purpose, like the reading activity in Case Study A. Rather, participants chose to develop their own uses of the new tool in order to integrate it into their workplace activities. As described in the previous chapter, most participants used the diary facility on the PDA and many found this particularly useful. The PDA diary could be synchronised with the Outlook calendar, an electronic diary held on a networked server that could be accessed via a desktop or laptop computer. As described below, this was one of the main benefits of using the PDA for this purpose. However, like the reading activity, the limitations of the PDA in this context included the small screen size and the awkward methods of data input, which made it difficult for some participants to record schedule changes in the diary.

This section begins with a description of the time management activity, followed by an analysis of interview data revealing the effect the PDA had upon the activity of time management in Case Study B. Again, concepts from activity theory have been used to guide this analysis, and the discussion is organised around the benefits and limitations that the PDA introduced to this activity.

6.2.1. The time management activity

Time management is a generic workplace activity that might be considered peripheral to the main work objectives of the participants in this study, whose jobs involved managing work groups, developing course materials, carrying out research, and preparing research reports and presentations. However, time management can also be considered an individual activity with its own objective – that is, to organise time effectively in order to manage multiple work commitments.

Geisler (2003) also used activity theory to describe time management as a unique activity, separate from the tasks it supports. She argued that time management is a recent social movement that has been advanced by “gurus” who espouse the benefits of goal-setting and dividing tasks into manageable units. She also cited the social movement of “professionalization” as an important aspect of the cultural history which has led to the widespread use of time and information management tools such as PDAs. This professionalization involved white collar workers having “the prerogative to control their working conditions” (p. 131). Thus, time management might be considered an activity associated with having some control over the other work activities in which people are involved. It can therefore be regarded as both a

unique activity in its own right, and a sub-set of actions contributing to other workplace activities.

Figure 6-5 provides an illustration of the time management activity system described in this chapter, outlining the tools used and the community, rules and division of labour that mediate the activity. The actions contributing to time management might include keeping a diary, setting up meetings, or doing a yearly work plan – each actions with their own goals, which together help to meet the overall objective of the activity. Within these actions are routine processes, or operations, such as discussing meeting arrangements with colleagues, writing appointments in the diary, recording schedule changes, or checking deadlines on a yearly calendar.

The following analysis looks at how the PDA changed the actions and operations that contribute to this activity, and also examines the effect the PDA had upon contradictions in the activity system. Unless otherwise specified, all interview quotes used in this discussion come from the first set of interviews that were conducted approximately five months after the PDAs were introduced.

The decision to use the Outlook calendar had a great impact on the activity of time management. This could be seen primarily in the effect the new tool had on the community and division of labour within the activity. As illustrated in Figure 6-5, the activity of time management took place within a community involving colleagues with whom participants made appointments, and secretaries who often had responsibility for managing the academics' diaries. Keeping a diary in electronic format changed the division of labour within this community. For example, one participant found that by using an electronic diary, which colleagues could view on their desktop computers, he was able to reduce his involvement in the process of arranging appointments:

I seem to be spending more and more of my time making appointments with people and if I can just say go away and you can sort it out and tell me when you're free to fit in with me, I don't have to reply to emails saying can you give me your availability for December, January and February. [...]
[The PDA] enabled me to store my diary electronically and that's slowly reducing my workload because I don't have to tell people when I'm available, I can say look at my electronic diary. I have had some meetings made electronically and that's been useful. (B06)

For those who already used the Outlook calendar, the PDA helped overcome a contradiction within the activity system caused by the tool's lack of portability. Previously, the Outlook calendar could only be accessed on the desktop or laptop computer, and therefore those who relied on this system rarely had access to their schedule information when attending meetings in other offices. Some participants described strategies they would use to overcome this limitation. For example, they might keep a separate paper diary, print out pages from the Outlook calendar, or

simply rely on their memory of the information contained within the electronic diary and make tentative appointments based on that memory:

What I did [before] was rely on my PC. I kept everything in Outlook and so I would, more often than not if I was in a meeting, someone would suggest a time, I would say 'I think that's free but I'll get back to you' and then the onus would be on me to say 'yes, I checked my diary'. (B09)

I used to print out my diary sheets from the computer and then carry them around and make scribbled corrections on them and then come back to the office and change them on the computer and do that kind of thing. (B10)

There was a contradiction, therefore, within the tools that mediated this activity. The electronic diary on the desktop computer was beneficial for some purposes, but it could not be used outside the office. For some people, this meant using two different diaries – paper and the computer diary – with all the problems that this entailed, such as keeping the information in the two systems up-to-date and having to record new meeting appointments twice. There was always a danger, therefore, of double-booking.

This could be particularly problematic for people who had secretaries managing their electronic diaries. For example, one participant (B11) said she needed to constantly check the desktop computer for appointments that had been scheduled by her secretary, so as to keep her paper diary up-to-date. There was, therefore, a contradiction between the tools and the division of labour of the activity. In order to share the diary-keeping activity with her secretary, it was necessary to use the Outlook calendar. But this conflicted with the more flexible paper diary – which could be taken outside the office, and therefore could be used when making appointments directly with colleagues while attending meetings in other offices.

Using the two tools concurrently required different actions: maintenance of the electronic diary and maintenance of the paper diary. The PDA, however, provided a portable version of the computer diary, which helped to resolve this contradiction.

This had the effect of reducing the number of actions necessary in this activity:

I don't have to do things twice. Like scribbling on the hardcopy printout of the Outlook diary and then coming back and transferring it in is two jobs. Doing it on the PDA and then putting it in to HotSync is one job so those jobs have now disappeared. (B10)

Therefore, the PDA resolved a contradiction within the tools of the time management activity system. Resolution of this contradiction meant that fewer actions were necessary, thereby simplifying the activity and contributing to its transformation.

6.2.3. Limitations of the PDA diary

Limitations of the PDA, such as awkward data input methods and the small screen display, made it difficult for some participants to fully integrate the new tool into the activity of diary management. The amount of information that could be displayed on the PDA diary was, of course, quite limited compared to how much could be viewed on a desktop computer or a paper diary. This meant that participants were unable to undertake actions that they were able to do easily on a paper diary, such as year planning. Viewing the diary on the PDA was quite different to looking at a paper diary, and this required some adjustment: “I feel that I don't visualise it in the same way as I used to and that may be to do with the way the diary is laid out on the page” (B03).

Furthermore, like the reading activity discussed in Section 6.1, awkward data input methods meant that, for some participants, previously operationalised processes –

such as entering an appointment in the diary – became actions that required individual attention. Each action was more time-consuming and required greater effort than it would have done had it been operationalised. Therefore, some participants found it difficult to keep up with other people when entering appointments in meetings, and they had to devise strategies to overcome these difficulties. For example, they would use abbreviated words and ignore punctuation. One participant said he relied on other tools to enter appointments in the PDA:

When I'm in a meeting and we're trying to arrange new meetings, which is something I do quite a lot, it takes me so long to enter an appointment in there that the discussion's moved on. So I don't do that anymore - I have a piece of paper with me and I see that I'm free from my calendar on my PDA, but I write down the new appointments on paper and put them in on my desktop machine and synchronise them. (B06)

Using the PDA required a new method for entering text and this meant that the process of entering the appointment in the diary became an action rather than an operation. In other words, there was a breakdown in the activity. For B06, the disruption to the activity that this caused was so great that he chose to revert to using other tools which enabled him to enter appointments in the diary using procedures that were already operationalised (i.e., handwriting and typing). As will be seen in the following section, this limitation also had an effect on the way some participants used the PDA as a note-taking tool, as part of the overall activity of information management in the workplace.

6.3. THE IMPACT OF THE PDA ON INFORMATION MANAGEMENT

In this section I turn to the activity of information management in the workplace, which, like time management, was one of the key activities that participants in Case Study B used the PDA to support. Like the previous discussion, then, this section examines data from Case Study B. The analysis focuses on two aspects of the information management activity: (a) the use of emails, and (b) the recording and storage of notes. Some participants used their PDA extensively to support these aspects of the information management activity, which is briefly described below.

6.3.1. The information management activity

Information management is another generic workplace activity, with the overall objective of managing information resources effectively in order for the subject to be able to achieve his or her main work goals. Therefore, as with the time management activity, this could be considered an action, or a series of actions, that is subordinate to other work activities. However, in this section I will discuss information management as a unique activity in its own right. Figure 6-6 illustrates the information management activity system in Case Study B. As described in Chapter 4, participants in Case Study B were all employed in academic or project-related roles in the Open University's Institute of Educational Technology. Therefore, their jobs involved keeping abreast of new technologies and current research, and communicating information about their own projects to colleagues and the broader research community. Thus, keeping track of information resources was an important activity in this work setting.

Information management encompasses various actions that can be supported by different features of the PDA. For example, it might involve reading, deleting and filing emails, it could incorporate the recording, storage and retrieval of notes, such as meeting notes and personal memos, and it could involve accessing specific information resources such as newspaper articles. These are some of the most prominent uses that participants in Case Study B made of the PDA, and they are each discussed further below.⁹ Again, this discussion is based on an analysis of the interview data in Case Study B and, unless otherwise specified, the interview quotes used are taken from the first set of interviews that were carried out for this study.

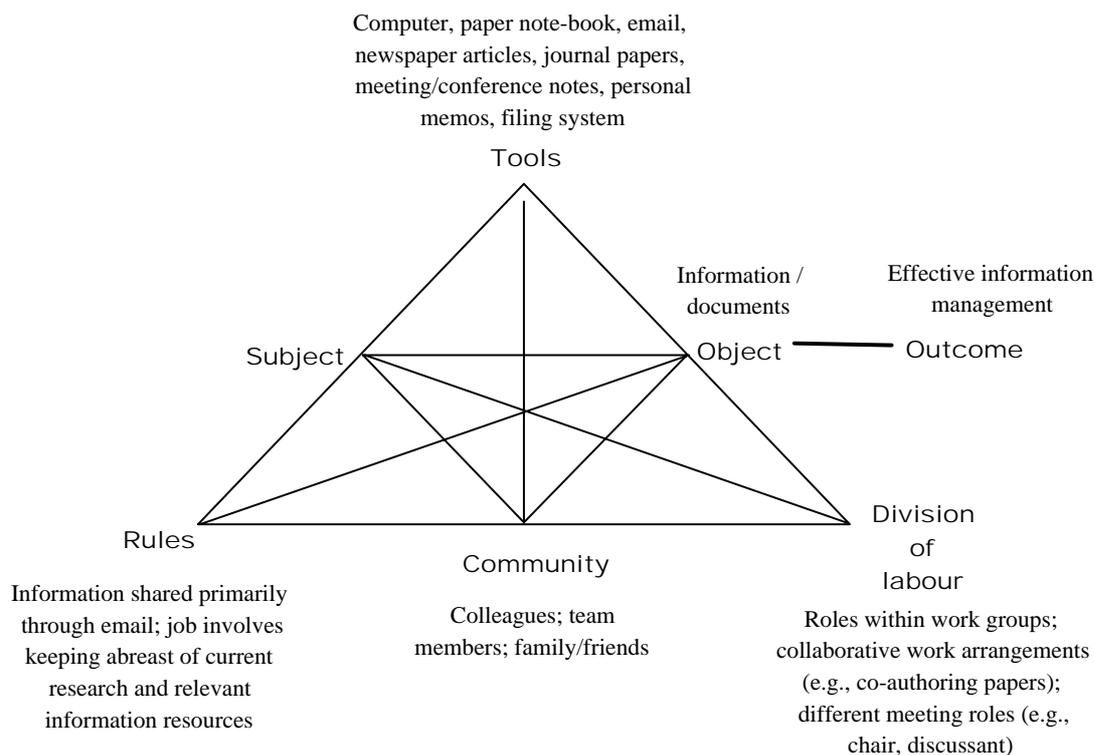


Figure 6-6. Information management activity system

⁹ The PDA was also used to store addresses and telephone numbers, but this function was not widely discussed in the interviews, so is not outlined here.

6.3.2. Email

Some participants found the PDA to be quite useful for downloading emails from the desktop computer, which they could then read while out of the office. They were not able to download emails “live” while on the move, as the PDAs did not have the capability of wireless connectivity. However, they were able to download the current contents of the email in-box when synchronising the PDA with the desktop computer. This meant that email use was no longer confined to an office environment. The PDA could be used to read and delete emails while the user had some spare time – for example, while on a train, while waiting for a doctor’s appointment, or during a meeting or conference when the user was not involved in the discussion. This helped to resolve a contradiction within the activity system between the rules governing email communication and the tools used for accessing emails – primarily the desktop or laptop computer.

Benefits of using the PDA to read emails

In this workplace setting there appeared to be a general unwritten rule that much communication and information sharing among colleagues would be conducted via email. This was particularly the case for those who were undertaking collaborative work with colleagues not based at the university, or with colleagues who were absent due to study leave or away at a conference. Therefore, participants in this study managed quite large email in-boxes, and they tended to check their emails on a daily basis when possible. Many of the emails they received, however, were not specifically relevant to them; these included house-keeping emails that were sent around the department or university, emails that were sent to discussion list address books rather than to a specific person, and unsolicited emails from unknown sources.

Included among these irrelevant or less urgent emails, were some that were directed to the specific person, sometimes requiring urgent action or attention. For example, there might be an email telling the recipient of changes to a meeting scheduled for the following day, or an email from a colleague about a collaborative paper that needed to be completed in time to meet an imminent deadline. Therefore, the process of reading emails involved a combination of checking, filing or deleting non-urgent and irrelevant emails, while seeking out messages that required urgent attention or follow-up action.

The workplace desktop computer was the main tool used to access email, although some participants also used home computers and laptops, and in some instances it was possible to check emails in specially equipped computer rooms when attending conferences. In most of these cases, however, the user was confined to a particular setting while undertaking the sometimes arduous task of managing the email in-box.

The PDA helped to overcome this contradiction:

The fact that I can synchronise emails at the end of the day if I've been in meetings all day here, is really useful, because it means I can then check them at home in the evening or on the way home, and just see if there's anything that's worrying. (B03)

I was able to scan through my emails at the end of the day ... Either at home or on the train to a meeting the next day. So out of the office. I would find if there was anything urgent then I would deal with it as early as I could. (B08)

The PDA, then, made it possible for people to manage their emails while away from the desk, freeing up the time spent in the office that would normally be taken up with the task of reading, filing or deleting emails. However, the PDA also introduced some limitations to this activity, as outlined below.

Limitations of using the PDA to read emails

One limitation of the PDA as a tool for reading emails was that it did not retain the file structure of the in-box on users' desktop computers, making it impossible to transfer emails to personal folders. Some participants managed their email in-boxes – which were subject to a strict size limitation – by filing emails into different folders that had been created for this purpose. In other words, emails would be removed from the in-box and categorised according to user-defined categories. The PDA, however, only downloaded the main in-box, which meant that emails that had already been filed were not available to read on the PDA. Furthermore, it meant that the process of filing emails was an action that could only be undertaken using the desktop or laptop computer. For this reason, some participants chose not to use the PDA to read and manage emails.

Furthermore, space-saving mechanisms on the PDA meant that long email messages were truncated and attachments could not be opened. This was particularly a problem for those participants whose jobs involved reading numerous documents that were sent via email: they could not access these documents when reading email on the PDA. They therefore used email on the PDA differently to the way they managed emails using the desktop or laptop computer. For example, the PDA would be used to deal with short emails, replying to messages that required simple “yes” or “no” answers or deleting emails that were no longer needed:

B11: Well, the potential problem with using it in that way [for email] is that you don't get the email attachments with it so things that you might have done, unless you've quite deliberately in some way downloaded those, you can't work in that way.

JW: So not having that information was a limitation?

B11: Yes, it did mean that you could reply 'yes' and 'no' to emails, but you can't actually work on the stuff that people have sent. Which is obviously not a problem working from home then I would be coming into the email through the web, so that I could do that. [...]

B11: I use it in that sense of being able to do things with email that I know I've got and occasionally deleting emails. I use it as something you can do in odd moments.

The PDA, then, still gave people the possibility of dealing with emails while away from the office; however, it did not enable them to use email in the way they had become accustomed when using other tools.

Another participant (B01), who chose not to continue using the PDA after a short time, had initially hoped to use the PDA to read emails while in meetings, so that he could make use of the time available when the discussion in the meeting was not relevant to him. However, he found that having emails on the PDA did not offer him any benefits over printing them on paper. Given that existing tools already helped him meet his objectives, there was no need to continue using the PDA. The importance of the relationship between the PDA and existing tools – and how this impacts upon the way the PDA is used – was discussed in Chapter 5. The following section, meanwhile, describes how participants used the PDA to record and store notes and the impact this had upon the activity of information management in the workplace.

6.3.3. Recording and storing notes on the PDA

A small number of participants used the PDA extensively to take notes. Others attempted to use the PDA for this purpose but found the data input methods to be too slow and difficult. For those who persevered, however, the PDA provided a valuable

way of creating and storing notes electronically. The possibilities introduced by the PDA in this context are described below, followed by an outline of the limitations of the PDA as a note-taking tool.

The benefits of using notes on the PDA

The PDA was used as a tool for both recording electronic notes and accessing notes that had been created on the desktop computer and downloaded onto the PDA. A key benefit of the PDA in this instance was that its portability provided anytime, anywhere access to selected information: “It was the electronic version of writing it on the palm of your hand” (B02) .

Participants who used the PDA as a note-taking tool were able to keep track of both personal and work-related information on the one device:

It is very useful for short notes to myself [...] So I'm using this like a little notebook all the time ... It is things I have to do but I don't put them down as to-do lists, I just have lots of these little notes ... It's everything from shopping lists as I'm wandering about thinking about what I need to buy when I go home tonight, to URLs to remember [and] passwords, so I'll take passwords with me when I'm logging on at other people's computers. (B10)

Many people kept the PDA either in their shirt pocket or in their handbag, and so it was always available when they wanted to record or access information. For instance, in an informal conversation, one participant (B05) told me how he had used the PDA to record the name of an Australian plant he had seen while out shopping. The same plant had been given to him as a present but until then he did not know its name or details of how to care for it. When he saw it, then, he was able to record the name in the PDA and look it up on the Internet when he returned home. This example illustrates how the PDA can be used as a personal learning tool.

Furthermore, unlike desktop or laptop computers which might, on occasions, be used by colleagues or family members, the PDA typically always remained in the hands of its owner. In this sense, as described in Chapter 5, some participants became quite dependent on the PDA as an information management tool. When used for this purpose, the PDA transcended work/home boundaries and became a truly personal tool:

The PDA is really personal. I don't have to worry about it, I can include personal documents on it. It's not heavy-duty personal stuff, just things like what do I need from my shopping. (B07)

A further benefit of the PDA as a note-taking tool was that it could be used in conjunction with the desktop computer. Typically, notes recorded on the PDA were transient notes. They would be transferred to the desktop computer to be incorporated into another document or email, or to be filed according to the user's information management system. This reduced the number of actions involved in recording and organising meeting notes:

You come back and by doing a bit more to the document, you have a complete document rather than a set of scruffy notes which you promise yourself you will write up when in fact, you know, with any distance from those notes it's really quite difficult to do on some occasions. (B09)

I've scribbled notes in a meeting [on the PDA] and then come back to make notes from the meeting and of course they're now in electronic format as the outline for what becomes the word document that I just copy and move over, instead of again having a bit of paper that I work from. (B10)

That is, previously there had been a duplication of actions: notes scribbled on bits of paper then had to be typed up on the computer. The PDA simplified this process by enabling notes to be recorded in electronic format, which could then be uploaded

onto the desktop computer when the two machines were synchronised. This facility was used extensively by one participant in particular (B09) who made substantial use of her PDA as a note-taking tool in combination with the foldout keyboard. As discussed in Chapter 5, this participant used the PDA and keyboard to take notes in seminars and conferences. Her ability to touch-type meant that she was able to record notes more efficiently than she would have done otherwise:

I find because I can type quite well, I can continue with my train of thought, listen to the person, and keep pace and perhaps take down something from the slide, whereas if I'd been writing it I'd have probably got to point two and almost not heard the next thing the person had said. (B09)

Typing notes on a keyboard, therefore, was an operationalised process and this freed up resources that could then be directed towards the action of listening to the speaker. Furthermore, notes recorded on the PDA were considered more “complete” than “scruffy” paper notes. Figure 6-7 shows the notes this participant took on her PDA, compared with paper notes that were taken when she was unable to use the foldout keyboard (which requires a flat surface to be used effectively). She found it difficult to maintain and re-use the paper notes, whereas the notes recorded electronically could be both filed on the computer and printed out.

In contrast, another participant expressed a preference for scribbling paper notes:

I think there is something very organic about scribbling on bits of paper. The bits of paper themselves are significant. They are a certain shape or a certain colour or a certain context and that's something that's quite difficult to replicate electronically. (B02)

This reiterates the point made in Chapter 5 that people have different personal preferences for work practices and so they will appropriate new tools in different ways in order to suit those personal preferences. In this study, some participants (such as B09) preferred to take electronic notes over paper, and so they adapted the PDA in order to make use of it as a note-taking tool (in this case, by adding the foldout keyboard). As described below, however, other participants found the text input mechanisms on the PDA to be too slow and difficult to use and this had a limiting effect on how the PDA was used as a note-taking tool.

Library Training Session PhD October 2003

Introduced by
 Endnote 7
 Basics
 One and a half hour session – talked to – no hands on practice
 Support for technical queries AACIS or your local ITSP
 And email address - library subject specialist – Non Scantlebury in the case of IET
 Look at the worked examples after the class
 Joe connected to the [getting help](#) pages on the library site...
 Take a look at the FEQ's – could be useful?
 Put a short cut for endnote on the desktop if you wish
 See what's new in endnote 7 - could be useful
 Best to create one library Joe said
 Inserting dividers or key words for example
 Creating a new library
 Must save the endnote library in my documents if you want it to be backed up and saved
 4 ways to get refs in
 Manually
 Import
 Connection file i.e. connect out...
 Direct export
 Reference types...
 Default journal articles...
 Electronic source... probably the one you would need to use for web pages
 Separate authors on one line
 Parker, P.L.
 call number = class mark = OU library number

Explore
 1/ look for where people have been careful & clear about their methodology.
 make notes on methodology & context
 2/ Gaps
 questions already answered
 3/ Who is doing what.
 which are the interesting/organised
 4) Alternative literatures in a topic area.
 5) Finding a focus.
 6) Knowledge already known.
 Sub topics –
 8) Sub divide topic into sub topics
 what it is about the links in the different literatures that you want to focus on.
 10) Conferences
 People
 effective rehearsal
 compare & contrast
 practice?

Figure 6-7. Notes produced on PDA compared with paper notes

The left image shows notes that B09 recorded on the PDA and subsequently printed out. The right image shows notes she also took on paper.

Limitations of note-taking on the PDA

The difficulties that some participants experienced when using the text input methods on the PDA can be illustrated by an incident I observed in which one participant (B01) attempted to use Graffiti on his Handspring PDA. As this participant had not learnt the specific Graffiti characters, the PDA did not recognise several of the letters he attempted. For example, he tried to write a lower-case *a* whereas Graffiti only recognises this letter when it is written in upper-case, as an inverted *v* (i.e., \wedge). He also attempted to write a lower-case *t*, taking the stylus off the screen to cross the *t*. The PDA interpreted this action as writing two separate letters.

Furthermore, it was not clear that the arrows on the screen separated the area designated for letters from the area designated for numbers (see Figure 6-8). The participant mistakenly believed that tapping on the arrow would create a dot or full-stop. In fact, tapping twice anywhere on the Graffiti writing area would have achieved this. This incident is an example of what Bodker (1991) called a breakdown, caused by applying familiar operations to a new tool. What this participant did not realise is that he had to learn new ways of writing – that is, develop new operations – in order to make use of the Graffiti system. This incident can be contrasted with the experience of another participant (B05) who went to great lengths to learn the Graffiti alphabet: he did the onscreen tutorial included on the PDA and spent time playing a game designed to teach users Graffiti. Through this process, he developed the operations necessary to use Graffiti effectively and consequently said he found Graffiti very easy to use.

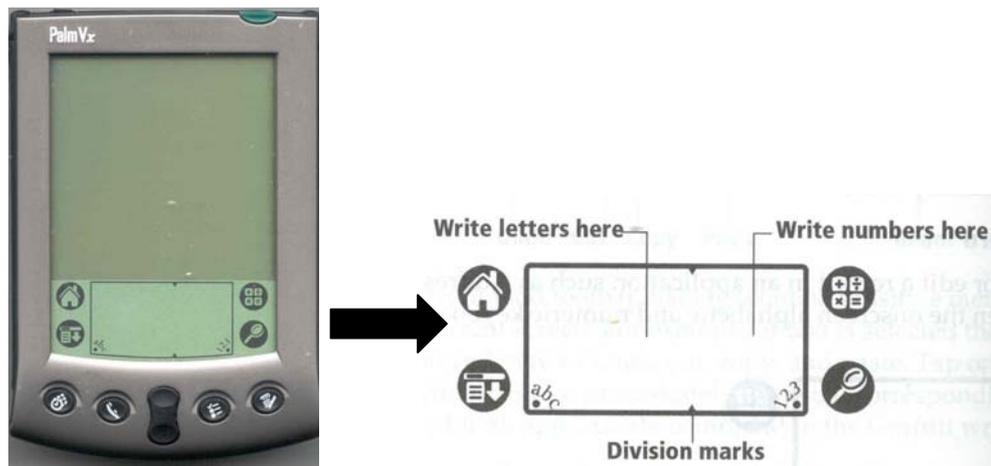


Figure 6-8. Graffiti writing area on Palm PDA

The Graffiti writing area is at the bottom of the PDA screen, shown in the image on the left. The image on the right shows how this is divided into an area for writing letters and an area for writing numbers.

For other participants, though, difficulties with the text input methods discouraged them from using the PDA to record notes. For example, B08 used the PDA to track a story in an online newspaper, a task which involved recording notes about the newspaper articles she had read. The PDA enabled her to undertake this activity while travelling, but she found it difficult to record notes on the PDA when on the train. Mistakes were frequent, and this meant she recorded fewer notes than she would have done using other tools. Another participant said he found the process of taking notes, using the onscreen keyboard on the PDA, detracted attention from the meetings he attended:

I had a number of meetings where I wanted to keep track of what was going on and if I tried to make notes using this method of input, I couldn't keep up. I would have had to pay more attention to the screen than I would to listening.
(B07)

In other words, it was an action rather than an operation to record each individual letter on the PDA. Writing notes on the PDA required focused attention directed towards the tool and this meant that other actions in the activity (for example, listening to the meeting discussion) could not be fulfilled. However, this participant also commented that, when he was required to take notes in meetings – for instance, when he had taken on the role of reporter in a collaborative working scenario – he did use the PDA for this purpose. In this case, he found the PDA useful as its clear screen and legible type made it easy to share the recorded notes with colleagues.

This example illustrates how the division of labour within the meeting impacted upon the way the PDA was used. When taking on the role of reporter in a meeting, this participant found the PDA invaluable because it enabled him to easily share information with colleagues. However, when he was not expected to carry out this role he did not use the PDA to take notes, as the actions it involved required too much conscious effort. Similarly, another participant (B04) said that she did not take notes in meetings because her role as chair of those meetings meant that it was important that she paid attention to the meeting discussions. Instead, she would rely on a secretary to record notes. Thus, there is a suggestion here that while the PDA changed activities in various ways, components in the activity system also had an effect on how the PDA was used. This issue was dealt with in the previous chapter. The following section, meanwhile, presents a model, based on the preceding analysis, which describes how new tools change activities. This model draws on concepts from activity theory to describe this tool mediation process.

6.4. AN ACTIVITY THEORY ANALYSIS OF TOOL MEDIATION

In this section, I present a model that describes how a new tool changes the activities it is used to support. I have labelled this model the *Tool Integration Process* (TIP) model, and it is shown in Figure 6-9.

In this model, the new tool is shown to introduce new possibilities and constraints, based on the notion of the task-artefact cycle (Carroll et al., 1991). These possibilities and constraints have various consequences. In the TIP model, I have drawn on the activity theory concepts of contradictions, actions/operations, and breakdowns, to describe these consequences. The possibilities of the new tool are shown to resolve contradictions in the activity system. Meanwhile, the constraints can lead to either non-appropriation of the new tool, or breakdowns in the activity system, the development of new tool-oriented actions which can subsequently become operationalised, or the adaptation of the new tool in order to overcome its constraints. In turn, overcoming the constraints of the new tool can lead to the resolution of further contradictions in the activity system. The components in this model are described in further detail in the following discussion, which draws on examples from the preceding analysis to illustrate how the PDA changed the activities it was used to support.

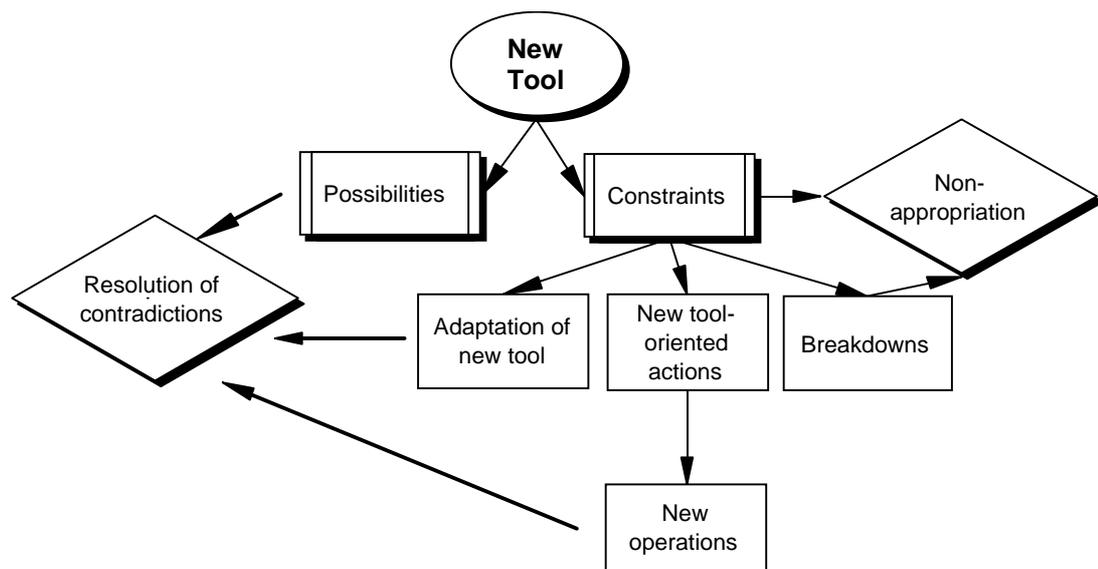


Figure 6-9. A model of the *Tool Integration Process (TIP)*

As shown in Figure 6-9, the possibilities that a new tool introduces may help to resolve contradictions in the activity system. This was the case in all the activities described in this chapter. For some students in Case Study A, the portability of the PDA helped to reconcile the activity of reading course materials with the unwritten rule that students must make use of every bit of spare time they can in order to complete their Open University studies. Previously, the course materials were only available on A4 pages collected in a ring-bound folder, which, for some students, was difficult to carry around and therefore was not always at hand when a spare moment became available to catch up on the course reading.

The PDA introduced similar possibilities to the time and information management activities in Case Study B. For instance, the portability of the PDA, combined with the fact that it could be easily synchronised with the desktop computer, resolved a contradiction within the tools of the time management activity. Previously, those

who used the Outlook calendar as a time management tool had to devise strategies to cope with its lack of portability, such as printing pages from the calendar, using a separate paper diary, or relying on memory when making appointments with colleagues. Each of these solutions created some conflict in the activity. In contrast, the PDA made it possible to carry a portable version of the Outlook calendar, reducing the need to undertake redundant actions (such as entering appointments twice) and making it easier to share schedule information with colleagues. Similarly, the ability to download emails from the desktop computer to the PDA at the end of the day freed up the time that participants spent in their offices reading and deleting emails. In this case, there was a contradiction between a rule of the information management activity – that email was the primary means of sharing information with colleagues – and the main tool used – that is, the desktop computer, which did not provide the portability needed to keep track of emails on a daily basis.

Of course, the PDA also introduced limitations to these activities, which were generally consequences of the device's portability. For instance, the small screen size and limited data input methods had a constraining effect on each of the activities. This was largely due to the new tool being incompatible with the operations that participants had developed from experience at using other more familiar tools. Bodker (1991) acknowledged that this limitation will occur whenever a new tool is introduced to an activity:

An important part of learning in work is to build up a repertoire of operations. When a new artifact is brought into a practice this practice will change. Even the most competent expert will probably have to change her repertoire of operations, and for a while she is returning to a lower level of competence. (Bodker, 1991, p.32)

Thus, on many occasions in the case studies described here, participants' "repertoires of operations" were not suitable when using the PDA. For instance, in Case Study A, students were accustomed to navigating through the course materials by flicking through pages and noting the physical location of headings. However, when using the PDA, they had to learn to respond to new contextual clues, such as a shaded progress bar at the bottom of the screen. Thus, as shown in Figure 6-9, they had to rely on new **tool-oriented actions**. That is, students were no longer able to focus on the main object of the activity (that is, the course materials). Rather, the tool became the focus of the activity. This could be most clearly seen in the use of text input methods in each of the activities described in this chapter. Many participants said that when using the handwriting recognition system or the onscreen keyboard on the PDA, they had to concentrate on creating each individual letter. Thus, when trying to take notes in meetings, for example, they had to focus on the PDA itself, rather than on the meeting discussion. In contrast, when using previously operationalised processes, such as writing notes on paper or typing on a keyboard, they were able to direct attention to the meeting discussion rather than to the mediating tools.

Device limitation can also lead to **breakdowns**, which, as discussed in Chapter 3, are "situations in which some unarticulated conflict occurs between the assumed conditions for the operations on the one hand, and the actual conditions on the other" (Bodker, 1991, p.27). A clear example of such a breakdown is the incident in which one participant (B01) attempted to apply normal handwriting rules to the Graffiti interface. In this case, the participant had assumed that his repertoire of operations for handwriting would be applicable when using the handwriting system on the PDA. However, in order to use Graffiti successfully he had to learn to write the alphabet

characters in a specific way. That is, he had to develop new operations for writing. This is what another participant (B05) set out to do when he made use of the game supplied on the PDA which is designed to give users practice at writing the Graffiti alphabet characters. In this case, learning to use Graffiti initially involved a series of specific goal-directed actions. Then, as each letter was mastered, the actions became operationalised, leading to this participant's sense of proficiency at using Graffiti. Thus, over time, the tool-oriented actions that a new tool warrants may be turned into operations.

There were also numerous examples in the case studies described here of participants adapting their use of the PDA in some way so as to overcome constraints of the new tool. Again, this was most apparent in the use of text input methods. For example, as described in Section 6.3.3, one participant (B09) made extensive use of her PDA in combination with the foldout keyboard, so that she could type notes in seminars. Other participants, in both case studies, made use of the desktop computer to fix errors made when entering text on the PDA, or to complete diary entries or meeting notes that were hurriedly made on the PDA. Thus, the TIP model shows that one possible response to the constraints introduced by a new tool is that users will adapt the way they use the tool in order to overcome those constraints. This adaptation is part of the process of tool appropriation; that is, making the tool one's own (Wertsch, 1998).

6.5. CONCLUSION

This chapter has addressed the second research question of the thesis: how do PDAs mediate learning and workplace activities? The chapter described data from Case

Studies A and B, which demonstrated how the PDA changed the activities of (a) reading for learning purposes, (b) workplace time management, and (c) workplace information management.

The purpose of the TIP model in Figure 6-9 is to illustrate the findings from Case Studies A and B, describing how the PDA mediated learning and workplace activities. Taken together, the ASTAM framework used in the previous chapter and the TIP model developed here, represent the two-way process of tool appropriation. That is, the ASTAM framework describes how the use of new tools is shaped by sociocultural factors, while the TIP model demonstrates that as a new tool is appropriated, it mediates the activities it is used to support. In other words, the TIP model describes how new tools shape activities.

However, the TIP model differs from the ASTAM framework in that, with the exception of the reference to contradictions, it does not refer to the concepts in Engestrom's (1987) activity system triangle. Rather, the TIP model describes the changes caused by a new tool primarily in terms of its effect on actions/operations and breakdowns. The TIP model does not represent how these changes would then have an effect on the activity system components of subject, tools, community, rules, and division of labour. Although Case Studies A and B did provide some evidence of how the PDA changed activity systems (particularly in terms of resolving contradictions between activity system components), the data were more informative about how the PDA changed the actions and operations that made up the activities. The relationship between the TIP model and the ASTAM framework therefore requires further exploration. This is discussed further in Chapter 10. Meanwhile, the

following chapters continue the exploration of the concepts of tool appropriation and tool mediation, reporting the findings of the final two studies that were carried out for this research.

Chapter 7

PDAs as Mobile Working Tools in Case Study C

This chapter describes the findings of Case Study C, which examined the use of PDAs in a large international organisation, known here as NatGasCorp (NGC). The aims of this study were twofold. Firstly, the study provided a rich context in which mobile technologies are used, enabling further analysis of how PDAs are appropriated and integrated into general workplace activities. Thus, the study contributes to the first research question of the thesis: how are PDAs appropriated as learning and workplace tools? It was also intended that the research help to inform the decisions made by the technology providers at NGC, giving them a better idea of how PDAs fit in to the users' work activities. In this chapter, activity theory concepts are used to address each of these aims.

The chapter begins with a description of the NGC setting, providing some background information about the introduction of PDAs in this organisation. This is followed by a closer look at the mobile working practices that were described by interviewees, and an analysis – based on the ASTAM framework – of how the PDAs were integrated into those work practices.

7.1. THE WORKPLACE CONTEXT: NATGASCORP

As described in Chapter 4, Case Study C involved interviews with 16 NGC staff members, who worked in various departments across the organisation. Table 7-1 gives a summary of the information provided at these interviews, which took place from July to September 2002. Not all interviewees used PDAs. However, those who did not use the PDA still provided valuable information about the work activities at NGC, and in particular their mobile working practices and mobile technology requirements. Two observations of staff training sessions were also carried out, and the data from these sources were supplemented by information elicited from meetings with members of the Information Technology (IT) team and emails exchanged with key informants. The company's web site and annual reports were also used to provide further information about the work setting.

The main objective of NGC is to explore and market natural gas resources around the world. The company is profit-driven and is listed on the London Stock Exchange. Therefore, maintaining shareholder value is considered to be an important aspect of the business. The corporation's headquarters are based in the UK, and many of the staff who work there are required to travel frequently to visit the assets and other overseas businesses. Therefore, this organisation provided a rich context in which to examine mobile working practices and the use of mobile technologies. In this chapter, the term *mobile working* refers to any work that takes place outside of the organisation's UK headquarters. This is typically in overseas offices, but can also include work that is done in hotel rooms, at home, or while travelling. (This is slightly different to the definition of mobile working offered in Chapter 2, which

included local mobility. However, for interviewees in this organisation, mobile working clearly meant travelling and working away from the head office.)

The type of work undertaken by NGC employees is widely varied but could largely be described as *knowledge work* (Blackler, 1995). Within the organisational literature, much emphasis was placed on knowledge sharing and skill development. In my discussions with NGC employees a common theme was the importance of communication among colleagues and the necessity of tools that support the constant sharing of information. It was this need which motivated the initial introduction of PDAs into the organisation. Palm PDAs were supplied to managers in 1999. Although they did not have wireless connectivity, and therefore could not be used as communication tools, they did have a facility for downloading the company Intranet site. The NGC Intranet was known as KITE (*Knowledge and Information to Everyone*), and was made available on the PDAs through AvantGo software (an application used to truncate and download selected web sites onto the PDA). The purpose of KITE was to provide a facility for storing company information, such as press releases, company policies, and staff details. It was hoped that having that information available on PDAs would make it more accessible for staff who frequently worked away from the head office.

However, at the time that I came to conduct this research, the PDAs were no longer being used for this purpose. Although some of the staff still used PDAs, very few people used them to download the company Intranet, and most used them simply as

electronic diaries and address books. The company's IT team was concerned about whether this was an efficient use of the PDAs.¹⁰

It appeared that several factors had contributed to this outcome. The staff member responsible for initially introducing PDAs and AvantGo software to the organisation left the company following a demerger in October 2000, and the project was not maintained. Furthermore, the use of the KITE system in general was disappointing. It was used as a repository of information that went out of date very quickly; therefore staff found it an unreliable tool for accessing current information. At the time of this study, the KITE Intranet was being replaced with a new Intranet portal that, it was hoped, would provide more real-time information and would be better designed to meet individual staff needs through personalisation of the tool. It was intended that the new Intranet would be initially made available to staff working in the head office and, over time, would be made available to other offices throughout the world and eventually to mobile workers through laptop computers or PDAs. Meanwhile, it was also intended that the Palm PDAs be replaced with new, higher-specification devices that, it was hoped, would provide users with a more effective mobile working tool that enabled the use of a range of powerful functions.

Therefore, this research was carried out at a time of considerable change in the organisation's use and provision of mobile technologies. The Information Technology department was in the process of evaluating employees' needs regarding mobile technologies, and changing the technology provision accordingly. It was

¹⁰ As discussed in a meeting with NGC IT staff, 21st May 2002.

therefore hoped that this research would provide the organisation with useful information about how people used mobile technologies in NGC.

Table 7-1. Summary of information provided by Case Study C interviewees

ID	Job Title	Main work activity	Mobile working practices	Is PDA used?	Comments about PDA.
C01 M	Risk Analysis Manager	Assessing risks associated with NGC assets.	Team members travel frequently - spend two weeks at a time in each asset. Risk Analysis Manager does not travel much himself.	No.	
C02 M	Risk Analysis Director	Overseeing audit activities.	Travels to assets where audits are being carried out, for a few days, to oversee audit.	Yes Diary & to-do lists	PDA has replaced A5 filofax/paper diary - PDA considered to be a much better tool for day to day use than the paper diary.
C03 M	Sao Paulo Asset Manager	Setting up a new business and creating a new office in Brazil.	Travels to Brazil twice a month.	Yes Synchronising calendar & contacts between desktop & laptop computer.	Finds data input difficult. Still uses printouts of Outlook calendar & scribbles new appointments on printout, rather than using PDA.
C04 M	Science Director	Determining whether a well site is of any value to NGC.	Team members travel to well sites to carry out data collection and analysis – although this is sometimes conducted remotely from NGC offices or home.	Yes Diary	PDA is considered valuable for synchronising the calendar.
C05 F	Executive Business Assistant	Helping to run office of Executive Vice President (EVP)	Travels frequently with EVP.	Yes Calendar and contacts	Always carries laptop, therefore some conflict between tools.
C06 F	Public Relations Manager	Communicating company information to the media.	Travels frequently to visit overseas assets. Needs to be available 24 hours as a press contact.	Yes Calendar and contacts	Would like to be able to use it for 'real time' information - e.g., press cuttings, emails.
C07 M	Government Liaison Officer	Finding out what governments want in terms of oil and gas assets and maintaining good relationships with overseas governments.	Travels overseas frequently. Also often travels to London.	Yes Calendar and contacts	Identified limitations due to synchronisation with Outlook (e.g., meeting notes on Outlook not accessible on PDA)
C08 M	IT Officer	Trying to reduce costs by reducing spending or workload; Making	Travels frequently for personal work (e.g., attends several conferences a year).	No	Previously used PDA. Did not find it useful.

		e-business solutions invisible.	Personal rule: works anytime, anywhere and does not distinguish between personal and work time.		PDA functions conflicted with laptop and mobile phone, which were always available.
C09 F	Human Resources Manager	To ensure smooth running of HR practices in NGC.	Does not travel often. Sometimes works from home.	Yes Address book	Does not like diary interface on PDA. Does not use PDA for emails because her in-box too big.
C10 M	Safety Manager	To ensure security of NGC staff and assets, particularly in dangerous or volatile cities and countries.	Travels frequently to visit assets.	Yes - Psion PDA Address book.	Previously used for diary but Psion not compatible with W2000. Generally positive about usefulness of PDA.
C11 M	Asset Management Consultant	Facilitation and governance of performance management systems in NGC assets.	Travels app. 4 times a year, to visit overseas assets.	Yes Address book	Still uses paper filofax - finds this easier to use. Does not carry PDA because cannot synchronise with laptop without use of cables.
C12 M	Legal Team IT Officer	Promoting knowledge-sharing in Legal Team through use of IT resources.	No mobile working. Works predominately in NGC offices.	No	Says Legal Team have no need for PDAs as their work involves the use of large documents.
C13 M	Business Development Officer	Analysing potential new markets for NGC and growing existing gas markets in overseas assets.	Travels overseas approximately once a month.	Yes Diary and address book	Sometimes uses PDA instead of laptop to carry short documents and emails, but says it is 'not useful' for this purpose because of data input limitations.
C14 F	Market Development Adviser	Analysing potential new markets for NGC and growing existing gas markets in overseas assets.	Travels overseas approximately one week in every four.	No	PDAs were originally only supplied to a certain level of management and the Market Development Adviser did not qualify.
C15 M	Knowledge Management Director	Creating systems NGC staff will use to store and share knowledge.	Typically travels every month or two months for a week at a time.	Yes Diary, contacts, meeting notes, managing expenses.	Finds PDA less useful, since using laptop with docking station - always carries laptop, therefore no need for

					synchronisation.
C16 M	PR Director	Looking after external reputation of NGC.	Does not travel much - other members of team are responsible for visiting assets. Has to be available out of hours as press contact.	Yes Diary, email, contacts	PDA is 'quite useful' and has replaced paper diary and address book. Would like to use for access to information while away from home or office.

7.2. PDAS AS MOBILE WORKING TOOLS AT NGC

In this section, I outline interviewees' descriptions of their mobile working practices, and examine how the use of PDAs fits in to those practices. This will be followed by a look at how participants said they actually used PDAs in NGC, and a description of participants' perceptions of the limitations of mobile technology provision at NGC.

7.2.1. Outline of mobile working in NGC

As shown in Table 7-1, the 16 interviewees came from a range of teams and departments in NGC. The interviews therefore provided a broad overview of a variety of work activities undertaken at NGC. Several of these activities revolved around the "assets" – that is, businesses set up by NGC in different parts of the world. These activities typically involved providing support for the assets or overseeing their business strategies: ensuring that the asset management strategies matched NGC's overall business principles (C11); assessing and analysing the business risk associated with each asset (C01 and C02); maintaining positive relationships between the assets and the local governments (C07); and ensuring the physical security of the assets and the personal security of staff travelling to visit them (C10). For this reason, a lot of the activities involved extensive travel to the

overseas assets, located in places as diverse as Europe, Egypt, India, Kazakhstan, Trinidad and Tobago, Brazil, and Argentina.

Other activities also involved extensive overseas travel. Some involved the expansion of NGC's business: setting up a new overseas office (C03); assessing potential new markets for NGC (C13 & 14); negotiating with local governments in countries in which NGC wishes to operate (C07); and exploring and analysing new natural gas and oil sites (C04). Other activities involved supporting general business processes in NGC: knowledge management (C08, C12, C15); human resources (C09); communications (C16, C06); and supporting the work activities of one of the Executive Vice Presidents (C05).

Many interviewees said they would work overseas for a week or fortnight at a time, typically travelling about once a month. The technical tools used to support this type of remote working included laptop computers, mobile phones and PDAs. For most interviewees, the laptop computer was considered indispensable. The actions that people undertook while working remotely would sometimes be indistinguishable from the actions they would do while based in the head offices:

[When working remotely] the auditors are doing exactly what they would be doing if they were here, which is interviewing people, getting documentation, considering whether things are being properly managed, run, controlled, reported and then writing issues from what they find, summarising that into a report. (C02)

I just happen to go and work in a different country one week and then I come back here. All the things that I do when I'm working that I do normally I have to do while I'm out there. It just exacerbates it because it's a lot more difficult. (C03)

Therefore, staff for whom mobile work involves the same actions as office work would need full office functionality – or as close to this as possible – from their mobile technologies. Both interviewees quoted above (C02 and C03) distinguished between “active” or “heavyweight” mobile working and “passive” or “lightweight” mobile working, by which they meant the difference between *producing* information – for example, writing reports and preparing presentations – and simply *receiving* information – for example, attending meetings and reading documents. This distinction is described in the following quote:

[In the mobile working seminar] I described two forms of mobile working – passive or active. I think passive is where you’re out, you’re at meetings, you’re in front of clients, you need to access your data, and that [PDA] should be fine ... I’m an active mobile worker in that I go away to do a week’s work, I just don’t happen to turn up here to do it, I go to Brazil. So I need full office functionality while I’m away ... I need the full system, I need to sit down and be able to create PowerPoint presentations, do Excel spreadsheets, write long word documents, have full email functionality and have equipment. (C03)

Many of the people I spoke to could be described as active mobile workers. While working remotely, their tasks would include collecting and analysing data, interviewing people and attending meetings, writing notes on their findings, producing reports, preparing and conducting presentations, and all the while maintaining contact with the office and other colleagues through email and mobile phones. For these workers, the notion that PDAs might be used *instead* of laptop computers was not considered practical.

In this respect, there was a mismatch between the needs of the staff I interviewed and the perception of those needs by the people responsible for implementing new technologies. In the mobile working seminar I attended, much of the discussion was

focused on the use of palmtop devices as information management tools, the implication being that they would replace laptops for many mobile workers. The assumption was that people needed mobile technologies to *access* information while on the move. The purpose of the mobile working seminar was to demonstrate a range of devices that would meet this need, as well as to gain feedback from staff about what they wanted from mobile technologies. However, the ultimate intention was to replace the Palm PDAs with “better value” devices that could be used more effectively to access company information and download emails while on the move. In other words, it was hoped that the new devices would fulfil the need identified when PDAs were originally introduced in the organisation. As described below, however, the PDAs had not, overall, lived up to expectations, although for some interviewees they did prove to be useful time and information management tools.

7.2.2. The use of PDAs in NGC

Of the people I spoke to who used PDAs, most had a Palm PDA, supplied by NGC. One participant (C10) used his own Psion handheld computer. The most common use that people made of these devices was as an electronic diary and address book. It was for this reason that the general perception in NGC was that people were not getting best value out of their PDAs. When PDAs were originally introduced in NGC it was expected that they would be used to read documents on the go, to download emails, and to access the company Intranet. Using the devices as electronic diaries and address books was perceived to be an inefficient use of the tool. This feeling was reflected in some of the comments made by interviewees:

I do not use it efficiently at all. It's just used for meetings and addresses. ... I would use it everyday but I don't use it for downloading information. (C06)

[Palms are] really just used as diaries and telephone books on the whole. That's how I use mine ... I don't think we use them as much as we could or should. (C04)

There's a whole lot of other features on there that I don't find it that useful for. (C07)

However, some staff disagreed with the notion that they were not getting value out of the PDAs. For these people, using PDAs as diaries and address books, or simply as a way of synchronising information between work and home computers, did add considerable value to their working lives:

I find the Palm very useful, specifically, the calendar and to-do list are probably the most useful, and the ability to synchronise it with the PC. (C02)

I think Palms have got a value and they're fulfilling that need. I think it's actually incorrect to say that NGC is not getting the value out of the Palm. I think it's somebody's perception of the fact that you can do more things technically, but the reality is that ... they have got a certain role in life ... And I think the role that the PalmPilot fills currently is okay. (C03)

I do get value out of going to a meeting with my Palm and somebody says 'can we meet again on Tuesday' and I can immediately do that ... if I save five minutes a day through not having to follow up or get a secretary to follow up and arrange another meeting, actually that pays back in a reasonable period of time, just from that alone. So I would ... challenge the view that we're getting low to no value out of the Palms. We may not need all the functionality of the Palms. Maybe there's an easier way of doing it, a cheaper device that is just a diary manager that plugs in and synchronises ... (C15)

Furthermore, some of the staff interviewed did use their PDAs as more than just diaries and address books. Some also used the to-do list function, some downloaded emails or small documents onto the PDA which they could then read while away from the office, and one interviewee said he used the PDA "occasionally note-taking

at meetings, occasionally looking at time differences [and] managing expenses when I'm on the road" (C15). However, he also added that these were tasks he might, on occasions, use the laptop for.

The redundancy of functions between the PDA and the laptop was a recurring theme in the interviews. One interviewee said that he "ditched" the Palm because he always carried his laptop and his mobile phone, which together could do everything he used the Palm for: "I was using the Palm to do things that I would rather have a laptop for. And since the laptop and the Palm and the mobile phone usually ended up in the same briefcase, I ditched the one that was least useful" (C08).

However, other interviewees felt the PDA could be used effectively in conjunction with the laptop. The PDA had the advantage of being "instant on" so it did not take several minutes to boot up like a laptop would. That is, when the "on" button on the PDA was pressed, the device was immediately operable. This was particularly useful for accessing information that was often required instantly in short bursts of time, such as telephone numbers and meeting information. As one interviewee said, "if all my numbers were stored on the laptop then I'd be extremely frustrated" (C13).

For some interviewees, the PDA could be used as an alternative to the laptop when the laptop was not required. For example, the Government Liaison Officer (C07) would use his PDA instead of his laptop when travelling to London for meetings. Similarly, the Risk Analysis Director (C02) would take his PDA and not the laptop if he was only going away for a few days and doing "lightweight" work, such as attending meetings. Furthermore, he preferred to leave the laptop at home when

travelling to countries where theft and personal security were major concerns. In this situation, the PDA would provide him with access to small amounts of essential information, making it possible to travel without the laptop. In other words, the PDA helped overcome a contradiction between the tools used (laptop) and one of the rules of mobile working (maintaining personal safety). However, this was only possible because of the division of labour; the Risk Analysis Director tended to do lightweight (passive) work while away, whereas his colleagues did heavyweight (active) work that required the use of a laptop.

In terms of the limitations of the PDA, these were, unsurprisingly, similar to those identified in the first two studies. For example, the screen size was considered too small for reading large amounts of information and most users found the data input methods to be slow and difficult to use. Some compared it to typing on a full-size keyboard which they preferred, and one participant (C03) compared it to using the small keyboard on his previous palmtop computer, a Psion, which he found much easier. Others said they preferred to scribble things on paper and were therefore reluctant to replace their paper diary. Some also disliked the interface of the diary on the PDA, preferring to be able to see more detail, as they would on a paper diary. Nevertheless, those who did use the PDA as a diary generally found they preferred it to a paper diary. As in the previous case study, the big advantage of using the PDA for this purpose was that it could be synchronised with the diary on the desktop or laptop computer. Most interviewees used the Outlook calendar so they could share their schedule information with secretaries and colleagues. Using the PDA as well meant there was no need to manually keep two separate diaries up to date. In this way, then, as in Case Study B, the PDA provided support for the division of labour in

the activity system, enabling more efficient use of the computer diary which could be shared with colleagues.

7.2.3. Contradictions and breakdowns in mobile technology provision

Communication technologies

During the interviews, I asked about any problems people experienced when using mobile technologies while working remotely. A common cause for concern was the breakdown in communication technologies while travelling in some parts of the world. For example, mobile phones would work in some countries but not others. Similarly, the ability to dial in to the company network would be unproblematic in some locations but would be slow, difficult or impossible in others. This was particularly a problem for those travelling to areas where there was not an established NGC office:

I think in terms of a company we don't necessarily cater very well for people like myself who sometimes go to countries where we don't have any support or infrastructure already. It's all based around dial in to the local office and use that system for access to your NGC account. But when we don't have an office it's not very easy. (C13)

Dialling in to the company network was important not just for using email but also for accessing shared files and storing documents on shared drives. However, email was considered an important part of most work activities and if a breakdown occurred with this tool, it disrupted the work activity:

[Email is] not essential but it is very useful. I mean just using the example at the moment, we've got two people in Argentina. I'm currently doing something for one of them. He left and he left me with certain things to tidy

up while he's there. Without email contact it's quite difficult. Because there have been several emails regarding that bit of work that I've been finalising for him. Not just from me but from other people who are commenting on it. Now he's out of that email loop. He doesn't know the various bits of information that have been exchanged since he left. So it makes it difficult. (C01)

When breakdowns such as this occurred, they highlighted a contradiction between one of the rules of the activity (maintaining contact with colleagues is important) and the tools, which in this case were insufficient for supporting the rule. The interviewee quoted above suggested a possible way of overcoming this contradiction would be to provide information resources – tools – highlighting the potential difficulties that might be encountered in the various countries and cities that NGC staff are likely to visit. Therefore, staff could be prepared for such problems and could devise strategies for overcoming them.

Similarly, another interviewee (C10) described his strategy for overcoming the limitation of not being able to use his mobile phone while in Latin America. In order to resolve this problem he would typically borrow a phone from the offices he visited. Ideally, the phone would be provided as soon as he arrived at the airport, and he would be sent an email beforehand with the telephone number, so he could set his own mobile to be forwarded to that number. Thus, this interviewee had established quite an elaborate method for overcoming the limitation of not being able to use his own mobile phone when travelling.

It seems that devising strategies for overcoming the breakdowns in communication technologies is a sensible solution to this contradiction. Ideally, however, staff would like to be able to use tools which enable them to maintain continuous and

seamless communication with their work community, even when working in varied and remote locations. However, such tools are dependent upon the infrastructure on which they operate, which can vary greatly from country to country.

As aforementioned, one of the purposes of this case study was to inform the Information Technology team's decision to replace the current Palm PDAs with other devices. One of the preferred functions of the replacement device was that it would enable access to emails while the user was working remotely. As part of this project, therefore, I researched what other tools were available that might fulfil this need and one device that looked particularly promising was the *Blackberry RIM*, a combination PDA and mobile phone. The main function of this device was to enable constant access to emails through its "always-on" capability. That is, the device would be connected to the company server, and emails that arrived in the user's inbox would be immediately downloaded onto the Blackberry handheld, without requiring the user to dial in or log on each time. I spoke to a staff member at O2, the company which was responsible for distributing the device in the UK,¹¹ and he told me that the always-on capability required the use of GPRS technology, which was not as yet globally available.¹²

¹¹ This meeting took place at the O2 offices in Slough on 25th September 2002.

¹² GPRS stands for 'General Packet Radio Service' and is a "system of transferring information over the GSM mobile phone network in small packets, e.g., an email would be broken down into lots of little packets of information and then sent over the network" (from The Carphone Warehouse 'Encyclopaedia Mobilia': <http://www.carphonewarehouse.com/commerce/servlet/gben-Home> Accessed 22nd March 2001).

At the time of my meeting at O2, the Blackberry RIM could operate in always-on mode in 15 countries, with the intention being to expand to 19 countries by the end of October 2002. However, these countries were predominately in Europe or other technologically developed locations and, even if the Blackberry RIMs were introduced in NGC, the problem of being unable to maintain communication while in countries such as Bolivia or Kazakhstan would still exist. Therefore, it seems this contradiction is not one that could be easily overcome with the introduction of new tools.

Heavy equipment and cables

Another difficulty people faced when carrying out mobile work activities at NGC was the need to carry heavy equipment, along with the various power cables and battery chargers needed to support the use of this equipment. For example, the following interviewee had a rucksack prepared with all the equipment she might need when working away from the office:

I have a rucksack sitting under my desk. It's huge. It has everything known to man in it that I would ever need on any of these trips. But it's heavy ... Because I carry a disk drive, a floppy disk drive in case people can't read CDs, I have a CD writer, I have the cables for various things. I have a power cable, I have a modem cable, I have in-flight travel charger ... I've got all the printer cables as well, and printer cartridges and batteries and - you name it, I've got it. (C05)

Therefore, to support the rule of mobile working at NGC – that is, that many employees are expected to travel frequently and undertake typical workplace activities (or actions) while away – it is necessary for some employees to carry quite a substantial array of tools and resources. An inherent contradiction in this system, however, is that the need to carry heavy equipment while travelling can create

difficulties for the mobile worker: “It’s hard work because it’s heavy. I have lots of bags, lots of cables, power supply problems, modem problems. It’s possible and I do it because it is possible, obviously, but it’s not easy” (C05).

On the surface, it would appear that handheld computers might offer a solution to this contradiction, enabling users to replace a heavy laptop with a lightweight PDA. However, as already discussed, many of the people I interviewed needed a laptop computer, with applications such as word processors, spreadsheets and presentation software, as well as a full keyboard and the ability to dial in to the company's network to access email and shared files. The actions people carried out while working remotely could not be adequately supported by a small handheld computer. For some, the weight of the laptop was preferred over the reduced functionality or smaller keyboards of other tools: “The laptops are pretty heavy at the moment. But I wouldn't trade the weight for a reduction in battery life or a reduction in keyboard functionality. I like the keyboard, it's a good size, [and] the screen's a good size” (C08).

When interviewees were asked about their ideal technology solutions for supporting mobile work, many said they would prefer not to have to carry so many cables:

[I'd prefer to] minimise the amount of bits of kit you have to carry. And definitely no cables because then you forget them when you're travelling and you can't work. (C11)

If I could have everything integrated, so that everything came to me in one place and I wouldn't have to use external things - I wouldn't have to use a hotel room with a dial-back modem, I wouldn't have to carry around so much equipment. [...] If you could have one charger for everything, that would be great, save you carrying all the cables around. (C05)

However, using a PDA did not eliminate the need to carry cables and battery chargers, particularly if the PDA was being used in conjunction with the laptop and therefore required synchronising with the laptop. For example, one interviewee (C11) said he did not like using the PDA because he could not synchronise it with the laptop computer while travelling, as this would involve carrying an extra piece of equipment (the synchronisation cradle). Instead, he would leave the synchronisation cradle on the desk at work and synchronise the two devices when working in his office. However, this was problematic when he was travelling for a substantial period of time (for example, if he was away for a fortnight) and could not keep the two devices up to date. Therefore, he did not find the PDA to be a useful tool.

Similarly, another interviewee (C13) said that he synchronised the PDA with his desktop computer when at work, but would often forget to do this if he was in the office for a brief time between overseas trips. He would therefore sometimes not synchronise the two devices for several weeks. This could mean that the calendar and contacts database on each device might contain different information, making it difficult for the user to manage his time and information effectively using both tools. One possible resolution to this problem could be the use of *Bluetooth* technology, which would enable laptops and PDAs to be synchronised without the use of cables. However, at the time of this study, this technology, although available, was not yet incorporated into many devices.

Nevertheless, for those employees who do not need a laptop computer when working away from the office, replacing the laptop with a palmtop computer could be a

feasible solution to the problem of having to carry heavy equipment. This was the intended solution put forward by the IT team in the mobile working seminar that I attended. One of the preferred replacements demonstrated in the seminar was an iPAQ, which has a colour screen and uses a Microsoft operating system that has better integration with Microsoft Office applications such as Word and Excel. However, one of the limitations of such a device is the need to charge batteries more frequently: the Palm PDAs that NGC staff were using would last approximately one month before needing to be recharged, whereas the iPAQs need to be recharged after approximately 36 hours. Given that the employees I spoke to tended to travel internationally for a week or fortnight at a time, they would need to carry a battery charger and power converter when using the iPAQ as a mobile working tool. It seems, then, that there may be further potential conflicts that may impede on the successful adoption of new devices such as iPAQs. That is, if the new device can only be used effectively with additional cables or battery supplies, it may not overcome the contradiction of having to carry various pieces of equipment to support mobile work.

In summary, then, the interviews and observation of the mobile working seminar demonstrated that the use of PDAs in NGC has been somewhat disappointing. Although some interviewees said they found the PDAs to be very useful tools, particularly for storing contact and calendar information, others believed they did not use the tools efficiently, reflecting the IT team's belief that PDAs should be used more extensively than they were in NGC. Furthermore, some of the functions of the PDA could be more effectively carried out on a laptop computer, with a full size keyboard and large screen. Therefore, some participants who always carried a laptop

found the PDA to be a redundant tool. In addition, the PDA was unable to resolve some of the limitations in the mobile technology provision at NGC. It may also be difficult for new devices to overcome such limitations.

In the following section, these findings are subjected to an activity system analysis of tool appropriation, based on the ASTAM framework that was used in Chapter 5. The purpose of this analysis is to demonstrate the applicability of the ASTAM framework in this context, as well as to identify some of the issues that may have played a part in the minimal use of PDAs in NGC.

7.3. APPLYING THE ASTAM FRAMEWORK TO CASE STUDY C

In this section, I will examine how each of the components in the ASTAM framework (subject, community, rules, division of labour, and existing tools) appeared to influence the way participants in Case Study C appropriated the PDAs. Figure 7-1 illustrates this analysis.

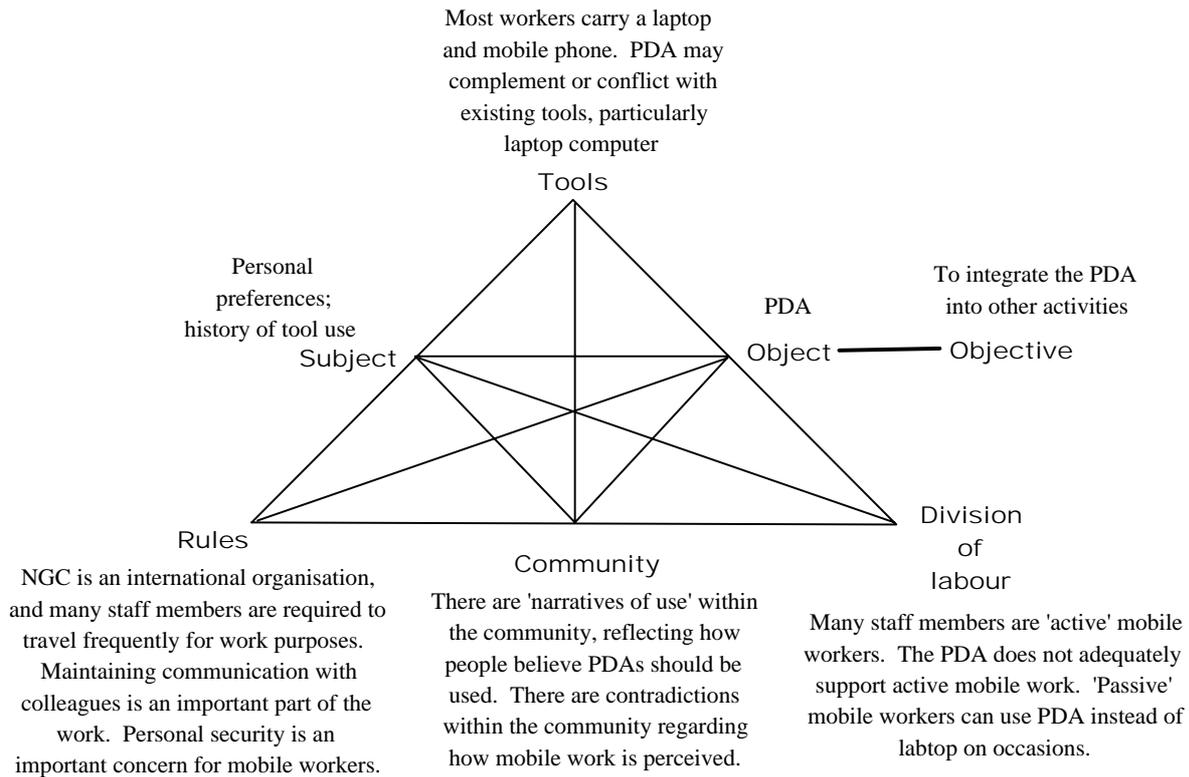


Figure 7-1. ASTAM analysis of Case Study C

As in the previous two case studies, participants in Case Study C varied greatly in the extent to which they had integrated the PDA into their work activities (see Table 7-1). Again, this study demonstrates that the user's personal preferences and past tool use are an important part of the tool appropriation process. In this study some interviewees expressed a preference for using paper over electronic tools, even when the paper tools appeared to be less efficient:

C11: I still use a paper filofax. I find it more easy.

JW: And can you elaborate on that, why the paper filofax is easier?

C11: Just for scheduling meetings, keeping notes, to-do lists. It's easier to type in, or just to write in and rub out. Rather than use the – we've got Palm ones – and I don't use the Graffiti style that well. It seems to me quite a long-winded process. [...]

JW: So does that mean you have to keep your paper filofax up to date with what's on the computer? How does that work?

C11: I'm very inefficient, aren't I, when I think about it? No, I tend to keep my paper thing filled up and then at the end of the day I'll just have a look and make sure the meetings the next day, I haven't got something booked or something missing.

Furthermore, as in the previous studies, many participants said they preferred to use keyboards for data input; their past experience of using computers had made the typing process more efficient than other forms of text input. Therefore, as Geisler (2003) argued, it appears that personal preferences for technology features are developed through the user's personal history of past tool use.

One interviewee described the disparity between the need to match tools with users' personal preferences and the predilection within organisations to provide users with standardised technologies and software:

IT groups tend to want standardisation, same software, because it's much easier to service it, low costs, and they're in control. Users, on the other hand, want something they're comfortable with ... And that's what IT should be working towards so that people can have the choice that makes sense for them and they provide the interconnectivity. Because the expensive part of it is in the interconnectivity, it's not in the individual devices ... It's almost like a piece of stationery. And to have someone say you need to have stationery that has a blue binder with this much spacing on the lines, is dealing with concepts that are no longer really current. (C07)

This quote suggests that there is a general contradiction between the needs of the subject in the activity system (the technology user) and the concerns of other members of the community (the technology providers). This interviewee also likened the PDA to a piece of stationery, which is a useful analogy. It reminds us of the tool history of the PDA. As Geisler (2003) described, precursors of the PDA

included paper diaries and information management systems, such as the Filofax and Rolodex. These tools have traditionally been viewed as stationery items in the paper-based office. Understanding this tool history provides insight into why the PDA is primarily used as a diary and address book, which may displace the notion that using the PDA for these functions is an inefficient use of the device.

Within the NGC community, there was a belief that PDAs were not being used as they should, that they were being used inefficiently and that they were therefore low value tools. These words were often used by members of the community – for example, by IT staff during the mobile working seminar and during an initial meeting that I attended at NGC, as well as by some of the interviewees. These are examples of what Churchill and Wakeford (2002) referred to as “narratives of use,” a concept that is included under the *community* node in the ASTAM framework. In NGC, the pervasive discourse surrounding PDAs was that they should be used as more than just diaries and address books. This message was clearly broadcast through the mobile working seminar, and had apparently made an impact on staff who felt that they were not using the devices efficiently. However, an examination of interview comments revealed that PDAs had actually been beneficial to some participants, particularly as a tool for supporting time management. This suggests that the decision to replace the Palm PDAs with higher-specification devices is based on assumptions of how such devices **should** be used, rather than a full understanding of staff work activities and how the PDAs fit in to those activities. In other words, in this organisation there was a “top-down” technology implementation approach, rather than one based on an analysis of users’ needs.

Furthermore, as described in the previous section, members of the community appeared to have incompatible beliefs regarding the nature of mobile work at NGC. Many of the people I spoke to could be described as active mobile workers; that is, they carried out work that involved the *production* of information, such as writing reports and preparing presentations. In contrast, the focus of the mobile working seminar I attended was on how to support mobile work that primarily involves *access* to information. Therefore, the intention was to replace the Palm PDA's with another palmtop device, such as an iPAQ, that could be used more effectively to access various information resources. The new palmtop device was also intended to be a substitute for a laptop computer. However, many of the people that I spoke to said they would need to use a laptop computer while working remotely in order to support the data production aspect of their jobs, despite also needing to have constant access to information.

This highlights the impact that both the *division of labour* and the existing *mediating tools* appeared to have on the decision to use the PDA. The division of labour within the community determined whether a staff member was an active or passive mobile worker. Those whose jobs involved undertaking actions such as collecting and analysing data, writing notes on their findings, producing reports, and communicating the results of their work to colleagues, were active mobile workers. For these people, a laptop computer was an essential mobile working tool, and was particularly important for those using sophisticated technical software. For example, as described by the Science Director (C04), petrophysicists were required to travel to gas and oil exploration sites to assess the findings at those sites. Their activities were supported by the use of specialist technical software, used to calculate the data and

produce large graphical charts of the analyses. When working remotely, petrophysicists used this software on a laptop computer. Similarly, employees in the Risk Analysis team (as described by C01 and C02) travelled to overseas assets to carry out analyses of the business risks at those assets. The technical tools used to support this activity included word processing and presentation software for preparing written and verbal reports, the Lotus Notes system for sharing documentation, and email for collaborating with colleagues. For that reason, all risk analysis officers used a laptop computer when working remotely.

In such cases, the laptop computer would always be available to the worker, and some functions that could be performed on the PDA could be more easily and effectively carried out on the laptop. Therefore, there was a conflict between the two tools, and there was little incentive for such workers to adopt and use the PDA. However, other staff members, whose jobs primarily involved overseeing the work of team members or attending meetings outside of the office, could feasibly replace a laptop with a PDA. For these people it was more important to have access to information, such as their calendar and contacts database, than to have the ability to produce reports using a computer with a full-size keyboard.

Unlike the analysis presented in Chapter 5, there was little evidence in this case study of participants becoming dependent on the PDA. I can only speculate on some of the possible reasons for this. It may be, for instance, that in many cases the PDA had not been successfully integrated into participants' work activities and so users did not feel any particular bond with the tool. After all, many participants felt that their use of the PDA was inefficient, suggesting that they did not find it a particularly useful

tool and therefore had not come to “care” for it in the way that some participants in the previous studies had (Christiansen, 1996). It could be said, then, that in such cases the tool appropriation activity had been unsuccessful: the objective – to integrate the PDA into the user’s work activities – had not been achieved.

The lack of evidence in this study that participants cared for the PDA could also be attributed to the fact that this study took place at a time when PDAs were no longer considered to be new tools in NGC. PDAs had been introduced to the organisation three years earlier. At the time of the study participants appeared to be looking forward to receiving the next set of mobile working tools. Therefore, any attachment people may have felt towards their PDAs could have waned over time, particularly as the Palms had not lived up to initial (organisational) expectations and there were now new hopes within the organisation for the provision of higher specification devices.

7.4. SUMMARY

This chapter has described the use of PDAs in a large international organisation. Conducting the study in an organisation like this provided an opportunity to witness the use of PDAs by mobile workers in a non-academic setting, thus providing a different context of use than that observed in Case Studies A and B. The study was also intended to elicit information about how employees at NGC used mobile technologies, particularly PDAs, thus contributing to further developments in the provision of mobile technologies at NGC.

As described above, the ASTAM framework was a useful analytical tool for this case study. As in the previous studies, the different components in the activity system

each appeared to exert some influence over how the PDA was used. This case study revealed that the community can be particularly influential. Members of the community contribute to narratives of use about how a tool should be used which may have an effect not only on how people make use of a new tool but also on how they evaluate that tool. Some participants in this study, therefore, felt that their use of the PDA was inefficient and that they were not getting best value out of the device, reflecting the discourse surrounding PDAs that was evident in NGC.

However, each user of a particular technology will belong to a different community and will respond to the narratives of use in that community in a different way. Thus, some participants in this study rejected the idea that they were not getting best value out of their PDAs and considered them valuable tools for supporting time and information management. This was particularly the case for those participants whose job roles allowed them to carry out their mobile working activities without the aid of a laptop computer. As in the previous studies, the PDA belonged to a suite of technologies that were used to support participants' work activities and, for some participants, there was some redundancy between the laptop computer and the PDA. In cases where the laptop computer was always available the PDA appeared to serve few functions that could not also be met by the laptop.

Recognising this, the technology providers at NGC have since changed the way they supply mobile technologies to employees. I contacted the key informants for this study approximately a year after the study was undertaken, and they told me how the technology provision at the organisation had changed. NGC no longer supports the use of Palm PDAs, which have been replaced with either mobile phones that have

PDA functionality or iPAQ handheld computers. Employees are now provided with two main mobile working tools. Those whose mobile work involves the extensive use of computer equipment are given a laptop computer and a mobile phone with the additional diary and address book functions on it. Meanwhile, those who do not have such a great need for a laptop computer are given an iPAQ and a mobile phone. It would have been interesting to revisit this organisation to find out how employees have reacted to these changes, and to see how the new tools have had an impact upon the work activities at NGC; however, access issues prevented this (see Chapter 10).

7.5. CONCLUSION

The purpose of this chapter was to contribute to the first research question of the thesis: how are PDAs appropriated as learning and workplace tools? Therefore, this chapter extended the analysis that was presented in Chapter 5.

In this chapter, I presented the results of Case Study C, which examined the use of PDAs as mobile workplace tools in a large international organisation. The technology providers in this setting were disappointed that PDAs were not being used as originally intended. Rather than being used as tools for accessing company information, they were primarily utilised as time management tools. That is, staff members had appropriated the PDAs in their own way; they had resisted using the PDAs in the way the technology providers had anticipated. Thus, this was an interesting context in which to examine the concept of tool appropriation, in which there was a disparity between technology providers' expectations of PDA use and the users' subsequent appropriations of the tool. This case study was useful for extending the application of the ASTAM framework, highlighting the influence of

narratives of use within the community, and emphasising that PDAs must complement, rather than conflict with, the other technologies that people use.

In the next chapter I will return to the concept of tool mediation, with a report of my experiences of using the PDA as a learning tool in the context of visiting a modern art gallery.

Chapter 8

PDA's as Multimedia Art Gallery Tour Guides

This chapter presents the findings of a study that examined the use of PDAs as multimedia learning tools at the Tate Modern art gallery in London. This study provided an opportunity to observe the use of wirelessly connected PDAs in a “real-world” setting, thus extending the data collected from the previous studies, which focused on non-networked PDAs and relied primarily on self-report methods. The intention of this study was to observe PDAs in use, providing an illustrative example of how PDAs can be used as learning tools in a museum environment. This was a timely concern: there has recently been an increasing interest in exploring how mobile technologies can best be used to support informal learning in museum settings (e.g., Hsi, 2003).

This chapter begins by providing background information about the trial project at the Tate Modern, in which PDAs were used to provide gallery visitors with information about selected exhibits. I will then report the observation and interview data gathered during my visit to the Tate Modern. Drawing on these observations and reflections, I will identify the possibilities and constraints introduced by the PDA, and discuss how these appeared to mediate the learning activity of visiting an art gallery.

8.1. BACKGROUND TO THE TATE MODERN PDA TRIALS

The Tate Modern opened in May 2000 and is part of the Tate Britain group of art galleries. It houses a wide selection of art that stems from the 20th and 21st centuries, including, for example, works by Claude Monet, Salvador Dali, and Jackson Pollock. It also frequently houses temporary exhibitions and conducts educational programs.

The act of visiting a museum or art gallery is said to be a *free-choice learning* activity (Falk & Dierking, 2000). According to Falk and Dierking, free-choice learning “tends to be nonlinear, is personally motivated, and involves considerable choice on the part of the learner as to what to learn, as well as where and when to participate in learning” (p. 13).

Museums and galleries have been identified as “an ideal context for this ‘free choice learning’ wherein visitors absorb ideas and connections at random, based on personal interests and triggered lines of inquiry” (Proctor & Tellis, 2003). However, some museum visitors might take part in a more structured educational program, for example a school field trip. In any case, the activity of visiting a museum or gallery presents many opportunities for learning.

Learning in a museum would typically involve interaction with other members of the community in which this activity takes place. For instance, people may discuss with each other their reactions to the exhibits, school groups might be set assignments to complete during the visit, and many visitors would be likely to make use of information provided by the museum curators so as to enhance their understanding of

the works on display. Fleck et al (2002) undertook a small study of visitor behaviour at the Exploratorium – a science learning museum in San Francisco – and found that social interaction was an important part of the museum experience (although the Exploratorium differs from other museums and galleries in that it is designed to foster social interaction). Fleck et al also noted that reading the information panels beside the exhibits appeared to detract attention from the exhibits themselves, but that visitors did seem to want to remember what they learnt in the museum, sometimes recording marginal notes in paper guidebooks.

Museum learning activities are often facilitated through the use of available technologies. Like many museums, the Tate Modern offers visitors the chance to use audio players with headphones to learn more about the artwork on display. The use of audio tours in museums and galleries has become common practice in recent years, particularly since digital audio technology became available. This meant the audio content was no longer confined to what could be recorded on a cassette tape, which users would have to listen to in a pre-defined order. Rather, with digital technology, a larger amount of content could be recorded, and users could have autonomy in choosing the order and length of their audio tours (Proctor & Tellis, 2003).

A natural progression from this format is to make use of handheld computers to provide visitors with multimedia content, such as text, videos, music and dialogue. This is what was intended by the first trials of PDA's at the Tate Modern, in 2002:

Unlike the existing audio tours currently used in UK museums, the Multimedia Tour allowed background information about the works on display

to be provided to visitors in a variety of different media on a portable screen-based device. Visitors could see video and still images that gave additional context for the works on display, and could listen to an expert talk about details of a work, while the details were simultaneously highlighted on their screen. Interactive screens encouraged visitors to respond to the art on view, for instance by answering questions or by layering a collection of sound clips to create their own soundtrack for a work. (Proctor & Burton, 2003, p. 53)

The use of PDAs as multimedia tour guides in the Tate Modern first took place during a trial from July to September 2002. Tate Modern staff conducted a comprehensive evaluation of this trial, eliciting responses from 852 visitors who took part in the pilot, as well as gaining information from more in-depth focus groups. Lessons learned from this trial were then put into practice in the second pilot, which took place in the latter half of 2003. It was during this trial that I visited the Tate Modern to conduct the observation study reported in this chapter. This study was conducted separately from the Tate Modern's evaluation; however, it was intended that my observation study would be useful as a supplement to the Tate Modern evaluation.

The first trial of PDAs at the Tate Modern made use of wireless technologies, delivering content over a wireless network to iPAQ handheld computers. Overall, the pilot was highly successful, with the majority of visitors who used the PDA saying that they believed it improved their visit to the gallery. Visitors apparently did not find it difficult to divide their attention between the PDA screen and the artwork on display. The most popular type of content on the tour included “an audio description of abstract paintings . . . accompanied by visual ‘zooming’ into the details being discussed,” interactive messages in which visitors responded to opinion polls about the artwork, and video footage – although this “was also considered a potential distraction” (Proctor & Tellis, 2003, p. 8).

The pilot also highlighted some user interface and technical limitations. These included users' misunderstanding of some icons, and the lack of a help menu, which led to the redesign of the interface. In addition, battery life on the iPAQ computers was poor, giving approximately one and a half hours of full performance.

The second trial, in 2003, used PDAs supplied by Toshiba. The intention, at this stage of the project, was to "focus on the interactive potential of the devices," including functions such as peer-to-peer communication and the facility for visitors to communicate with the gallery and send information to their home email accounts (Proctor & Burton, 2003, p.55). It was also intended that during this trial the multimedia tour would expand on the content and facilities that proved to be particularly popular in the first pilot study, that is, "to pinpoint the most successful methods and refine them to create specifically tailored multimedia learning models for visitors" (*ibid*). This trial, then, provided a rich context in which PDAs were being used as learning tools, thus contributing to this thesis an interesting illustration of the potential for PDAs as informal learning tools. My observations of the use of PDAs in this context are described further below.

8.2. UNDERTAKING THE PDA TOUR

As described in Chapter 4, this observation study took place during a one-day visit to the Tate Modern gallery in December 2003. The visit was planned following consultation with the Tate Modern curator responsible for the PDA trial. I took part in the trial myself, and also observed a volunteer, known here as Matthew (D01), who took part in the tour alongside me. Matthew was on holiday in England. His

visit to the Tate Modern was undertaken as part of his activities as a tourist in London. Aged 24, Matthew matched the profile of the intended users of the PDA tour, which was targeted at the 16-25 age group. Both Matthew and I considered ourselves to have minimal background knowledge of modern art, and so taking part in the PDA tour was an opportunity to further our understanding about the work on display. Furthermore, Matthew had not taken part in an audio tour of a museum or gallery before, and so the experience was quite novel to him. We took approximately two hours to complete the tour, using the PDA to access information about each of the 19 works included in the tour.

In addition, I spoke to four other visitors to the gallery about their experiences of doing the PDA tour. These informal interviews were opportunistic; interviewees were selected because they were the other people taking part in the PDA tour at the time of the study. However, one limitation of this method of selection is that I did not have the opportunity to speak to any “real” gallery visitors; instead, the people I spoke to were themselves gallery workers who were taking part in the trial in order to evaluate the use of the PDAs in this context for their own purposes. The data provided by these informal interviews are summarised in Table 8-1. The following discussion describes my observations of the tour, drawing on my own experiences as well as those of Matthew and the other visitors I spoke to.

Table 8-1. Summary of information provided by interviewees in the Tate Modern study

ID	About the interviewee	Summary of comments
D01 M	Also took part in observation (Matthew)	Had not done an audio tour before and found this to be a good way of finding out more information about the exhibits. He preferred this to reading the information on a board. He particularly liked the interactive elements of the tour - e.g., the opinion polls and games.
D02 M	Tate Gallery employee	Thought the PDA tour was a good idea but needs a bit of work to clean up technical glitches and interface problems. Liked that users can set their own pace; liked being able to view the map on the PDA; found text messaging option limiting; felt the painting he was currently looking at ('Clarinet & Bottle of Rum') was not enhanced by PDA content; would like to see PDAs available in other museums and galleries in the future.
D03 F	Works for another gallery; visiting Tate Modern to test out PDAs.	Purpose of visit was to test out PDAs so not a typical gallery visitor. Felt that she was focused more on using the PDA than on looking at the art work on display. She believed this could have been due to the novelty of using the PDA or because of the focus of her visit.
D04 F	Works for another gallery; visiting Tate Modern to test out PDAs.	Felt that this PDA tour was the best example she had seen. Not sure whether the PDA enhances the gallery experience or distracts you from the exhibit. Found it awkward to carry around the pen stylus, PDA and pen and paper. Thought the option of seeing information in sign language was a great idea for the hearing impaired. Tried texting but it didn't work. There was no option to scroll down the list of names. Said it would be more useful for groups (e.g., school groups) rather than individual visitors.
D05 M	Works for another gallery; visiting Tate Modern to test out PDAs.	Found that there were elements of the tour that worked particularly well, for example, finding out about the context of the artist creating the work (e.g., seeing pictures of Monet's garden, hearing about world events that were taking place at the time, and so on) - he found the information about history and visual cues particularly helpful for understanding the work on display. Technical 'glitches' when using opinion polls and text messages were frustrating. Felt that the PDA tour would be a good way to engage kids. Found the icons too small. Would prefer to be able to use fingers instead of stylus to interact with device - not currently possible with large hands. Found the pen-based input awkward. Said that if you are used to using PDAs you would know what to do but novice users may not realise that they have to physically tap the screen with the pen. Found that he was focused on the artwork that was included in the PDA tour and did not spend much time looking at the other exhibits, so the PDA was biasing the audience to look at a specific artefact. He would prefer to get information from images as his attention is drawn to information presented in a visual format. He felt there was a need to balance the time spent looking at the screen versus looking at the object on display. Sometimes he felt that he was too busy looking at the screen and forgot to look at the artwork. He would like to see this option to be provided as a choice for people visiting other galleries and museums.

8.2.1. The PDA set up

The PDA tour provided information about 19 selected works on display in the "Landscape/Matter/Environment" exhibition, a permanent collection on the third floor of the gallery. When visitors collected the PDA, staff provided a brief

introduction to the use of the device and recorded users' details, including email addresses, which were linked to the specific device the visitor had received. This enabled use of the "email home" feature, whereby visitors could elect to send information about particular works to their home email addresses. The device was also linked to the user's name, so that when using the peer-to-peer communication facility other visitors could send messages to a particular person.

The PDAs we were given had clear colour screens, with icons on the screen. Tapping on an icon with the pen stylus opened the corresponding tour item. Headphones were also provided, through which we could listen to the audio content of the tour. The PDA was attached to a neck-strap (see Figure 8-1) so that it could be carried hands-free.

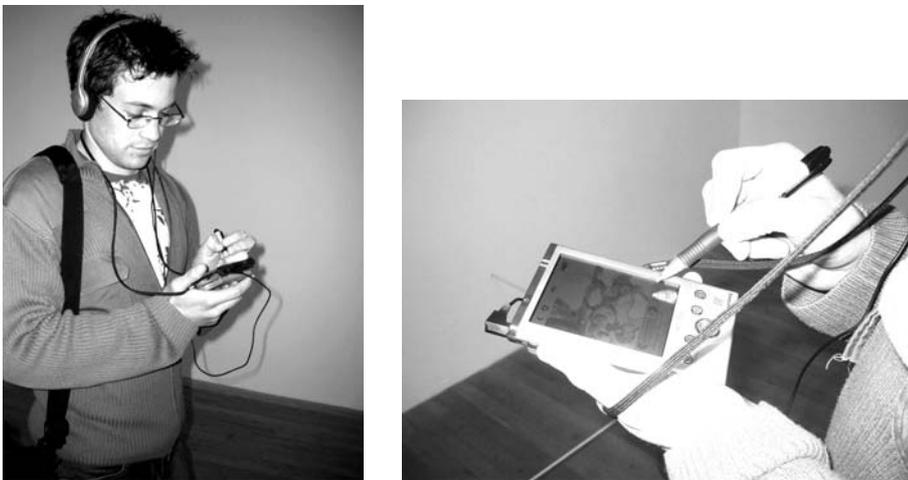


Figure 8-1. Using the PDA in the Tate Modern

It did not take long for either Matthew or me to become familiar with the screen interface, which was fairly simple and uncluttered (although we had both used similar technology before). To access the multimedia content on the tour we opened

the main navigation menu by tapping on the “home” icon (this icon was always visible at the top of the PDA screen). This displayed a number of options, including to view a map of the tour area, to select a work, to access gallery information, to send a text message, and to access the “juke-box,” which listed selected music associated with the artwork. One of the most obvious ways of accessing information about the works on display was to tap on the “select work” option. This displayed a screen showing a number pad; the user would then use the stylus to enter the number of the work he was currently looking at. The numbers associated with each work were displayed on the wall beside the exhibit in the gallery. I found these sometimes difficult to make out, particularly when there was a crowd surrounding the display. An alternative method, which was favoured by Matthew, was to tap on the “map” option and to select your location on the map, which would then display the options that were available for that particular work.

Clearly there was a potential here for a context-aware system that could be used to tailor the information on the PDA to be relevant to the user’s location (Hsi, 2003). This would have eradicated the need to either select the appropriate work number or choose the relevant location on the map; instead, the information on the PDA screen would be updated as the user moved between exhibits. However, due to technical difficulties that were encountered during the first stage of the trial, a context-aware system was not used during the second trial (Proctor & Tellis, 2003).

Once a work had been selected on the PDA a further menu appeared, showing the contents of the information provided about that work. The audio contents were divided into three or four sub-headings, and selecting one of these began the tour,

with the information relayed through the headphones. There were also, for some works, options to hear interviews with the artists or other people involved in the work, to listen to music, to view video footage or to look at zoomed images of the artwork on the PDA screen while listening to an associated dialogue about that aspect of the work. Some of these uses of the PDA are described below, with reference to specific examples that we encountered when undertaking the PDA tour.

8.2.2. Multimedia content – some examples

Multimedia content on the PDA tour provided information about the works on display in a variety of formats, such as through the use of audio dialogue, music, video, and still images. In the following discussion I describe some of the more salient examples where these different formats were used in combination to interesting effect.

“Contextualising” the artwork - Pollock’s Summertime

One of the exhibits included in the tour was a painting by Jackson Pollock, entitled “Summertime: Number 9A” (1948). When creating this painting, Pollock’s aim was “to work directly from his unconscious [which] led to a radical process of dripping and pouring paint over large canvases placed flat on the ground” (Tate Modern, 2003). The PDA provided the opportunity to view video footage of Pollock using this unique method. Furthermore, there was also the option to listen to music associated with this piece. According to the information provided in the audio tour, Pollock named this artwork after one of his favourite pieces of music, a “summertime rag.” Visitors taking part in the PDA tour could therefore select the title of the music from the menu displayed on the PDA screen and listen to it through the headphones while simultaneously viewing the artwork on display. This provided

the visitor with further insight into the context of the painting, creating a link between the artist's world and the painting the artist had created.

This use of multimedia content to *contextualise* the painting – that is, to provide further information about the environment in which the work was created – was mentioned by one interviewee (D05) as a particularly valuable use of the PDA. He said that he appreciated being able to view images of the garden that was the inspiration for Monet's "Water Lillies" painting, or to hear details of historical events that took place at the time a work was created. Thus, it appears that providing further information about a work in various media formats could be a valuable use of the PDA in this context.

Braque's Clarinet and Bottle of Rum

The content provided on the PDA tour included the use of still images on the PDA with accompanying dialogue. One example of this was the information provided to explain the detail within a cubist painting by Georges Braque – "Clarinet and Bottle of Rum on a Mantelpiece" (1911). The detail within this abstract painting is difficult to make out, apart from the objects hinted at in the title. The information available through the PDA, however, included a precise description provided by one of the Tate curators, with the relevant sections of the painting simultaneously highlighted in an image on the PDA. I found this to be useful and informative, but one of the people I spoke to (D02) felt that the PDA did not add anything to his experience of viewing this particular painting. Our difference in opinion could have been due to our disparate knowledge of art; D02 actually worked in the Tate Modern gallery and was taking part in the tour to see what the PDA offered. In contrast, my own background knowledge and experience of art is quite limited. This is similar to one

of the findings of the 2002 Tate Modern PDA pilot, where “visitors with extensive art backgrounds were less satisfied by the content on the tour, and would have preferred more research-oriented content and facilities” (Proctor & Tellis, 2003, p. 5). For visitors like me, however, the PDA was usefully employed to combine audio narrative with images on the PDA screen, making it possible to view details in the painting that might have otherwise been overlooked. This suggests that it may be valuable in this learning context for the information provided on the PDA to be tailored to suit the background and experience of each user.

Garden shed explosion

The combination of images on the screen with informative dialogue was used to provide detail about many of the works included on this tour. This technique was particularly useful for describing large installations that contained several (sometimes ambiguous) objects. One such installation was the 1991 work by Cornelia Parker entitled “Cold Dark Matter: An Exploded View.” This installation featured objects suspended from the ceiling, surrounding a single light bulb. The installation was framed by fragments of wood, which represented the garden shed in which the objects had once stood. The display had been created by exploding the garden shed.

Information about the display was presented in various formats on the PDA. For instance, there was an audio recording of an interview with the army major who had been employed to conduct the explosion. He described his reactions to the initial request to carry out this work (“I thought it was the beginning of an elaborate hoax”) and detailed how the explosion was executed. There was also video footage showing the work being assembled.

In addition, this item on the tour included a “touch-and-hear” option, whereby an image of the work was displayed on the PDA screen, with circles surrounding certain aspects of the work. Tapping the stylus on one of those circles initiated an audio dialogue which provided information about that particular aspect of the work. Thus, the dialogue accompanying the “Cold Dark Matter” installation provided further information about those objects circled on the PDA screen, such as a bicycle, fragments of wood, and other objects that once stood in the garden shed. This method differed from the technique used for the Braque painting (as discussed above), in that users had to select which aspects of the exhibits they wished to hear more about. Thus, there was an element of interactivity in this component of the tour; that is, users had control over the format and content of the tour. This potential for interactivity was also explored in other uses of the PDA, as described below.

8.2.3. Interactive games and polls

The PDA tour included a small number of games and opinion polls, whereby visitors were invited to respond to a question or take part in a short activity. Although this appeared to be a valuable use of the PDA, technical difficulties meant that we could not make full use of these features. For instance, the first opinion poll we encountered was in the “Rothko Room,” featuring a series of paintings by Mark Rothko, which each emphasised particular colours and together were designed to invoke certain moods in those viewing the paintings. An opinion poll on the PDA asked users to select whether they were feeling happy, calm, depressed, anxious or claustrophobic. However, once the selection had been made (by tapping the stylus on the corresponding option), the screen appeared to freeze.

Both Matthew and I were able to resolve this breakdown by tapping on the home icon and returning to the main menu. However, I noticed another visitor at this point returning her PDA to the distribution desk. Such technical problems are inevitable in a trial that aims to test out new uses for a particular technology. Nevertheless, this breakdown did cause a shift in focus from the activities of viewing the work on display and taking part in the opinion poll, to the act of resolving the technical breakdown, thus disturbing our participation in the learning activities.

Another technical breakdown occurred when we attempted to take part in a “surrealist game” associated with Salvador Dali’s “Lobster Telephone” (1936) exhibit. Selecting this option on the PDA caused the screen to freeze for both Matthew and I, which again had to be resolved by returning to the home menu. The process of returning to this menu meant that the audio tour was interrupted; we had to reselect the number for that work to return to the tour contents.

However, one game that was successful was an activity in which the user had to match each of four paintings to its corresponding season when viewing a series of works called “Four Seasons” by Cy Twombly. The paintings were shown on the PDA screen; to do the activity the user had to drag the season name (for example, “summer”) across to the appropriate image on the PDA, using the stylus. Matthew particularly enjoyed this activity and correctly matched each of the images with its corresponding season. Conversely, I found the images on the PDA screen to be too small to accurately ascertain which images on the PDA belonged to which paintings on the wall. This again illustrates the disparate reactions visitors might have to different aspects of the PDA tour.

8.2.4. Peer-to-peer communication

The PDA tour included options for visitors to send text messages to one another. This facility was accessed through the main navigation menu, by selecting the “TATE.txt” option. Once selected, two further options were revealed: to “read txt messages” or “send txt messages” (sic). In order to send a text message, the user had to select a recipient from the list of names of the other visitors currently using PDAs in the gallery. There was also the option to send a group message to everyone on the list.

Matthew and I sent messages to each other a number of times to assess the potential of this feature. We found it to be an interesting use of the PDA, but limited in the choices offered. Similarly, one interviewee (D02) said he found the text message facility “a little puzzling and limiting.”¹³ It was limiting because users were not able to create their own messages, but had to choose from the options available. That is, pre-written messages were shown on the screen and the user had to select which message she wanted to send. However, these messages represented the type of communication that might be considered peripheral to the main activity of learning about the artwork on display. For instance, they included items such as “I am hungry” or “I am tired.” It was not apparent, in this study, whether such messages would be useful to visitors or enhance the learning activity in any way.

In fact, from my observations of the actions of visitors who were not using PDAs, it appeared that peer-to-peer communication was successful without the use of text

¹³ This is not a direct quote, but is taken from my hand-written notes, recorded at the time of the conversation.

messaging. Many visitors were with companions or in groups; they would typically discuss their reactions to the exhibits amongst themselves. For instance, when I was looking at the display of Salvador Dali's "Lobster Telephone," two school girls approached the display and exclaimed to each other: "How weird!" Such spontaneous and dynamic interactions might be difficult to emulate with text messaging, particularly if users are not given freedom to create their own messages. Thus, this feature appeared to constrain the activity rather than enhance it.

The text messaging facility was also beset with technical problems. For instance, it was not possible to scroll through the list of possible recipients of the message. When I tried to do this – by placing the stylus at the bottom of the list – the PDA did not respond and the screen froze. I had to return to the home menu in order to continue using the PDA. One interviewee (D04) said that she also experienced this problem. This was an example of a breakdown caused by the novel interface of the PDA, creating a situation in which the user did not know how to respond to the device. Both the interviewee (D04) and I were attempting to apply our knowledge of this type of interface – where scrolling options are usually available – despite there being no apparent facility for scrolling through the list. Our incorrect use of the device in this instance led to a technical breakdown which disrupted the activity, causing us to focus on the resolution of the breakdown rather than on the activity itself.

8.2.5. Email home

Another facility on the PDA gave users the option to “bookmark” sections of the tour. Information pertaining to the selected works would then be sent to the user’s email address. However, this option did not appear to work. Although I bookmarked some items and did later receive an email, the email did not actually contain any of the information I had selected. Furthermore, this facility did not offer users much flexibility regarding the information that could be sent home. For instance, users could not capture their thoughts and reactions to the works on display.

Such a facility might have eradicated the need to take notes using pen and paper – which I observed many visitors doing. Using the PDA while also taking notes on paper proved to be problematic, for both myself and one of the interviewees (D04 – see Table 8-1). Although the PDAs were apparently wearable – with the addition of the neck-strap – users still needed to hold the PDA at an angle in order to view the screen. The device, therefore, remained a handheld tool. Thus, I struggled to keep hold of my note-book, pencil, PDA, and stylus. In fact, during a clumsy attempt to switch between the pencil/note-book and the PDA, I lost the stylus, which disappeared through a floor grate!

This point is relevant because I noticed during the tour that many of the visitors (not using PDAs) were taking notes using pen and paper, including students in school groups and individual visitors. This raises a question about how PDAs might be easily used alongside other handheld artefacts when the user is truly mobile (for instance, walking around a museum).

One way that this could be overcome is to enable users to take their own notes on the PDA, and then send those notes home. However, it is important that the interface is kept simple so that it does not detract too much from the learning activity, particularly since visitors are only likely to use the PDAs for a relatively short period. This context of use was quite different from that explored in the previous case studies, where users had personal ownership over the device and had the opportunity to become familiar with the interface over much longer periods of time. As discussed in previous chapters, data input methods on PDAs can be slow and difficult to use, particularly for new users. Therefore, this solution presents a contradiction: how to enable users to input text on the PDA while also retaining a simplistic interface.

This problem was also encountered by Fleck et al (2002) in their study of handheld tools in the Exploratorium museum in San Francisco. They found that offering too many functions on the PDA was confusing for users and detracted attention from the museum experience, so they chose to focus on one function – providing a “remembering” tool so that users could record information about particular exhibits to refer to at a later time. They provided visitors with a tag that could be swiped against the exhibit, so the corresponding URL for that exhibit would be stored and added to the user’s visit record, which would be given to the user at the end of the visit. Initial studies showed that visitors liked this facility and that they found it easy to swipe the tags to record information. There was “no indication that this disturbed their engagement with the exhibit or their companions” (p. 20). Most of the people studied did choose to look at the URLs after their visit to the museum, and several “saved comments with their pages” (p. 20). Therefore, it was possible for visitors to

record individual comments, but only when viewing the web site after their visit to the museum. Thus, the problem of enabling visitors to record their own notes while also using a handheld tool such as a PDA, was not resolved. This is a relevant issue for future research.

8.3. SUMMARY: HOW THE PDA MEDIATED THE LEARNING ACTIVITY

The PDA tour at the Tate Modern gallery was generally well-received by the people I spoke to, although technical problems meant that some of the functions were difficult to use. In particular, the interactive games, opinion polls and text messaging options were beset with technical difficulties. We encountered many breakdowns when using these facilities, which caused some disruption to the learning activity.

A more successful use of the PDA, however, was the utilisation of multimedia content to deliver information about the works on display. For instance, photographs, videos, music clips and interviews with artists and other relevant people, were used in combination to provide visitors with a rich array of information that portrayed the context surrounding the creation of the work on display. Furthermore, the use of zoomed images and accompanying dialogue helped to explain the content of some of the more abstract artwork included in the exhibition. I found this to be a particularly informative feature, although another visitor – who had more extensive background knowledge of art – felt that this facility did not enhance his understanding of the work.

Therefore, the PDA introduced many possibilities and constraints to the activity of learning in the Tate Modern art gallery. The main possibility – the use of multimedia content – appeared to enhance the activity, expanding the type of information available to visitors. The text messaging option, which it was hoped would also introduce a new possibility to the activity, actually appeared to constrain, rather than enhance, the activity. It did not successfully emulate the more dynamic and spontaneous verbal communication in which museum visitors engaged. Meanwhile, the technical difficulties, novel interface, and awkward means of carrying the tool, also constrained the activity, causing temporary breakdowns and shifts in focus from the activity to the tool itself. In particular, the need to hold the PDA in one's hand, along with the accompanying stylus, made it difficult to also take notes on paper, which might be an action that some visitors would undertake when touring a museum for learning purposes. Therefore, further research is warranted to ascertain the strategies learners use when visiting museums, and to determine how new technologies such as PDAs can best support those strategies.

As aforementioned, this study was limited in scale. I was only able to speak with five visitors to the gallery who had also taken part in the PDA tour (including the volunteer who took part in the observation study). Four of those interviewed were not typical users. One (D02) was an employee at Tate Modern who was taking part in the PDA trial to see what it offered, while three interviewees (D03, D04, and D05) were visiting from another gallery with the explicit purpose of testing out the PDA tour to see if it was something they would like to implement in their art gallery. For this reason, caution must be taken in drawing conclusions from this study. Nevertheless, this study did provide a valuable illustration of a particular use of

PDA's as learning tools, thus contributing to an overall evaluation of the potential for PDA's to be used as learning tools in different contexts.

8.4. CONCLUSION

This chapter described an observation study of the use of PDA's as multimedia tour guides in the Tate Modern art gallery. In this context, the PDA introduced many possibilities and constraints. Examining these provided some insight into how PDA's might mediate the sort of learning activities that take place in museums and galleries. For instance, the multimedia facilities on the PDA made it possible to contextualise the artwork on display in a way that would not be possible with audio tours or information boards next to the displays. On the other hand, the constraint of not being able to simultaneously take notes while using the PDA might detract from the learning activity, making it difficult for visitors to record personalised notes of their learning experiences. This highlights the need for further research into how people learn when visiting museums and how tools and technologies can best support that learning.

Although this study was small in scale, it provided an interesting "real-world" example of PDA's being used as informal learning tools. This has raised issues that will be of interest to other investigators exploring the potential use of PDA's as learning tools in a museum context, an area that has been receiving much attention in recent years (e.g., Hsi, 2003).

This chapter concludes the presentation of the fieldwork data. The next chapter will revisit the findings of the four studies and consider how they have contributed to the overall aims of this thesis.

Chapter 9

Discussion

This chapter will review the findings of the four studies reported in this thesis. The purpose of this review is to summarise the main findings of this research with reference to the aims that were outlined in Chapter 1. As stated in Chapter 1, this research set out to examine the use of PDAs as learning and workplace tools. The purpose of this research was not only to establish how useful earlier models of PDAs were as learning and workplace tools, but also to develop an empirically-grounded definition of the related concepts of tool appropriation and tool mediation. Therefore, this chapter will begin with an overview of the evaluative strand of this research, examining how the PDA was perceived as a learning and workplace tool in the four studies. This will be followed by a discussion of how the research contributes to an understanding of the two-way process of tool appropriation and tool mediation.

9.1. AN EVALUATION OF THE PDA

The case study approach adopted in this thesis provided an opportunity to examine the use of PDAs in a range of different learning and workplace settings. In addition, the use of interviews as the main source of data made it possible to evaluate the PDA from the perspective of the user. This served to emphasise that each user of a new tool is an individual person who chooses to use that tool in his or her own unique ways. Thus, it is not possible to determine the overall value of the PDA as a learning

and workplace tool: the PDA had a different value and a different meaning for each interviewee. Nevertheless, the following discussion will sum up the findings regarding how well the PDA was received in each of the study settings, beginning with an overview of the use of the PDA as a learning tool, and followed by a discussion of its value as a general-purpose workplace tool.

9.1.1. As a learning tool

In this research, I examined the use of PDAs as learning tools in two distinct settings:

- 1) In a distance education context where students on an Open University course used the PDA to read course materials (Case Study A).
- 2) In an informal learning setting where visitors to an art gallery used the PDA to learn about the exhibits on display.

The purpose of these evaluations was not to ascertain whether or not the PDA improved learning in these settings. Rather, I wanted to examine how users perceived and used the PDA, and how well they believed the PDA supported their learning activities. The findings suggested that participants differed greatly in the way they responded to the device and in how valuable they believed the PDA to be as a learning tool.

In Case Study A, for instance, I spoke to a small number of “champion users” who were enthusiastic about the PDA and the benefits it offered. Some of these students did not actually use the PDA supplied for the study but instead used a PDA they had provided themselves (this was certainly the case among many of the students who participated in the follow-up interviews). Therefore, it could be assumed that these students had generally positive attitudes towards the use of PDAs. Some students

used the PDA not only to read the course materials that were supplied for the study but also to download their own reading materials (e.g., A11, A12), to take notes in preparation for course assignments (e.g., A13, A09), and to help organise their work and family activities (e.g., A09, A14, A04, A15). Examining the experience of these students alone would paint a generally positive picture of the PDA. However, an overview of the questionnaire findings reveals a more complex situation.

Of the 35 students who responded to the post-questionnaire, only 10 said they used the PDA more than once a week to read the course materials. Only five students found the PDA *very useful* as a reading tool, while quite a large proportion – 15 students (43%) – found it *somewhat useful*. Meanwhile, over 20 respondents said they found it *somewhat* or *very difficult* to read course materials on the PDA. Thus, it appears that while many students found the PDA useful (or at least somewhat useful) as a tool for reading course materials, many students also felt the PDA was quite difficult to use for this purpose.

These findings are difficult to interpret without reference to the interviews, which provided a much richer understanding of how and why people differed in the way they used and responded to the PDAs. For instance, Jane (A09) – whose experience was discussed in Chapter 5 – was one of the more enthusiastic PDA users in this study. However, she found the PDA difficult to use as a reading tool as it caused eyestrain, resulting in headaches and blurred vision. Nevertheless, Jane's evaluation of the potential for the PDA to support her learning activities was overwhelmingly positive. For Jane, the portability of the PDA was a key benefit, enabling her to fit the reading activity around the many other activities in which she was involved.

Having “anytime, anywhere” access to learning resources is particularly important for distance education students who typically have to fit their learning around other activities such as work and family commitments (Jones et al., 1992). Therefore, using mobile technologies to provide access to learning materials could be particularly valuable in this context. However, this positive outcome must be countered by recognition of the negative experiences that students also encountered. As outlined above, many students found the PDA difficult to use as a reading tool. Some of the reasons for this difficulty, as discussed in Chapter 6, included that familiar navigational clues were missing, students could not gain an overview of the contents of the text, and it was difficult to skim-read through the text. Thus the characteristics of the device that made the PDA valuable in this learning setting – its small size – also made it difficult to use as a reading tool.

The observation study carried out at the Tate Modern provided a contrasting setting from that explored in the first study. In the museum context, there was not so much scope for people to develop their own uses of the PDA. Users in this context would typically be transient users, using the technology only during the course of their visit to the museum (although they may also use a similar device in other learning or workplace contexts). In this setting, the PDA took the place of a museum tour guide, providing visitors with background information about the works on display. However, users still had some control over the content and format of the tour: they could select which works they wanted to find out more about, and then elect to listen to particular components of the tour, such as interviews with artists or descriptions by museum curators.

It is difficult to draw conclusions from this study about how well the PDA supported learning in this setting. As aforementioned, this study was small in scale, and I did not examine how or what participants learnt during the PDA tour. Furthermore, the people who took part in this study were not visiting the gallery for learning purposes, but were focused on the activity of using the PDA, testing its functions and assessing its value as a tool for enhancing the museum experience. Nevertheless, this study served as an illustration of a particularly interesting use of PDAs as informal learning tools. My observations, described in the previous chapter, suggest that this use of the PDA could be a valuable way of providing art gallery visitors with multimedia content that contextualises the work on display. As described in Chapter 8, when I used the PDA for this purpose, I found information such as video footage, music, and zoomed-in images of the artwork with accompanying dialogue, useful for clarifying the context and content of the work. However, the value of the PDA in this context again depends on the background and experience of the person using the new tool. Not all museum visitors would find the same content, presented in the same format, equally useful, as was demonstrated by the disparate reactions of the small number of visitors I spoke to during this study. Therefore, it may be useful for multimedia content such as this to be tailored to suit different types of users.

9.1.2. As a workplace tool

Case Studies B and C examined the use of PDAs as general-purpose workplace tools. In Case Study B, 11 staff members in an academic department (IET) used PDAs as time and information management tools. In that study, I examined how PDAs came to be integrated into participants' workplace activities, and how use of the new tools changed over a two-year period from the time the PDAs were first introduced in this

setting. During the first set of interviews, which took place approximately six months after participants had started using the PDA, interviewees were overwhelmingly positive about the value of the PDA as a workplace tool. For instance, eight of the 11 participants said they found the PDA to be a very useful tool, and nine participants said they used the PDA every day. As discussed in Chapter 6, the PDA was particularly useful as a time management tool, providing a portable electronic diary that could be synchronised with the Outlook calendar on the desktop computer. Some participants also used the PDA as a note-taking tool and as a way of managing the email in-box while away from the desktop computer.

Not all participants used the PDAs for these purposes, however, and some participants found that these activities were not easily supported by the PDA. For instance, some participants struggled with the text input methods on the PDA and preferred not to use the foldout keyboard in social settings such as group meetings (e.g., B06). Meanwhile, other participants either adapted the way they used the PDA (e.g., B09 used the PDA in combination with the foldout keyboard), or learnt to use the handwriting recognition system (e.g., B05) in order to utilise the PDA as a portable electronic note-taking tool. This again illustrates that participants varied in the way they adapted, used, and integrated the PDA into their activities.

Because Case Study B examined the use of PDAs over a two-year period, I was able to observe how participants' perceptions of the PDA, and their use of the device, changed over that time. As shown in Table 5-2 in Chapter 5, which summarises the information provided by the interviewees, some participants' enthusiasm for the PDA and use of the device waned over the course of the study. In some cases, this

was due to characteristics of the device, such as battery limitations or poor screen calibration (e.g., B02, B10). In other cases, this was due to loss or damage of the device (e.g., B03), while some participants had actually changed jobs during the course of the study and so their use of technologies had changed accordingly (e.g., B02, B07). One participant (B09), who was particularly enthusiastic in her use of the PDA, found that the device continued to be a valuable tool when she gave up her job and became a full-time PhD student. In her case, she was able to use the PDA as a note-taking tool in course seminars, and also began storing her referencing software on the PDA. Thus, the PDA was a truly multipurpose tool: while for many students in Case Study A the PDA became a valuable workplace tool, for this participant in Case Study B the PDA accompanied her migration from work to learning activities.

Case Study C examined participants' perceptions of PDAs three years after they had been introduced in a large international organisation, NGC. The aims of Case Study C differed from the previous studies in that it had a dual purpose: to both contribute to the general aims of this research, and to inform future decisions about mobile technology provision at NGC. Thus, my role as a researcher in this study was interpreted by many interviewees as a mediating role between the technology provision staff and the people I spoke to. This was largely beneficial to the research; in general, participants were quite forthcoming about their perceptions of the benefits and limitations of mobile technology provision at NGC, and were keen for their voices to be heard. However, it could have also contributed to the largely negative evaluation of the PDA; participants were expecting their PDAs to be upgraded in the near future, and were aware of the IT team's concerns about the limitations of the Palm PDAs.

As discussed in Chapter 7, it appeared that there were strong “narratives of use” regarding how PDAs should be used in this organisation (Churchill & Wakeford, 2002). Because the PDAs had not been used as anticipated (as tools for accessing the company Intranet while on the move), it was widely believed that staff were not getting “best value” out of the devices. However, this research raises questions about the assumptions regarding best value and what it means in particular contexts. Some participants felt that using the PDA as a portable electronic diary did add considerable value to their work activities. Others felt that the PDA was not a valuable tool because they had other technologies, such as laptops, which better served their needs. This research suggests that rather than assessing the value of a tool on the basis of whether it was used as expected, it may be more appropriate to look at how that tool has come to be integrated into users’ activities, and evaluate it on that basis.

It could also be that, as in Case Study B, the enthusiasm for the PDA among NGC staff had waned over the three years since the tools were introduced. That this occurred in Case Study B is in line with Jennie Carroll and colleagues’ depiction of technology appropriation (Carroll, Howard, Vetere et al., 2002). They argued that technology appropriation is not stable; once a technology has been appropriated, it is continually evaluated, reassessed, and updated. Use of a particular technology, then, may decrease over time, as it becomes replaced by other technologies or if it no longer adequately serves the needs of its user (after all, users’ needs also continually evolve). The contributions of the present research to the concept of tool appropriation are further summarised below.

9.2. TOOL APPROPRIATION

As stated in the introductory chapter, the main purpose of this thesis was to develop an understanding of the related concepts of tool appropriation and tool mediation, grounded in the context of an evaluation of the PDA as a learning and workplace tool. A central argument of this thesis has been that these concepts are interrelated and cannot be divorced; together, they represent the two-way process by which new tools are integrated into users' activity systems. This idea draws on the literature that emphasises the "coevolution" of tasks and artefacts and the "reciprocal shaping" of technology and society (e.g., Brosveet & Sorensen, 2000; Carroll et al., 1991; Harper, 2002; Heath & Luff, 2000; MacKenzie & Wajcman, 1985). That is, while new tools are said to have an impact on the social setting into which they are introduced, features of the social setting also shape how new tools are used. This two-way process is illustrated in Figure 9-1. The following discussion reflects on how the research described in this thesis contributes to an understanding of the two-way process of tool appropriation and tool mediation.

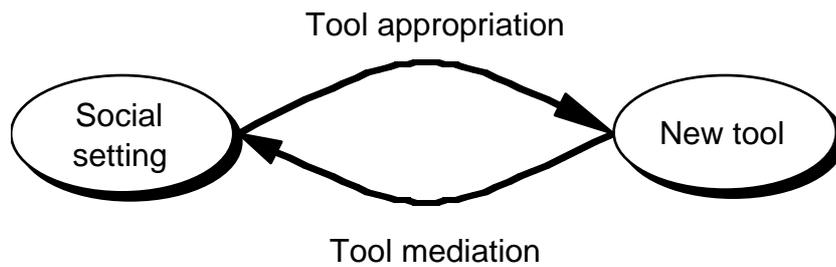


Figure 9-1. The two-way process of tool appropriation and tool mediation

The description of tool appropriation offered in this thesis is largely informed by activity theory, and focuses on identifying how sociocultural factors have an effect on the way new tools are used. The *Activity System Tool Appropriation Model* (ASTAM) builds on Engeström's (1987) depiction of an activity system, which describes activities as sociocultural systems directed towards a single objective. Through the operations of the activity system, this objective is transformed into an outcome. The ASTAM framework describes tool appropriation as an activity system in itself, where the objective of the activity is the tool being appropriated. This is a departure from the more established uses of activity theory, where technical artefacts are traditionally viewed as mediating tools in an activity system. However, while I acknowledge that technical tools do mediate activity (as discussed below), I also believe that activities can be directed towards the use of a particular tool. This is what I have described here as the tool appropriation activity, represented by the ASTAM framework, reproduced below in Figure 9-2.

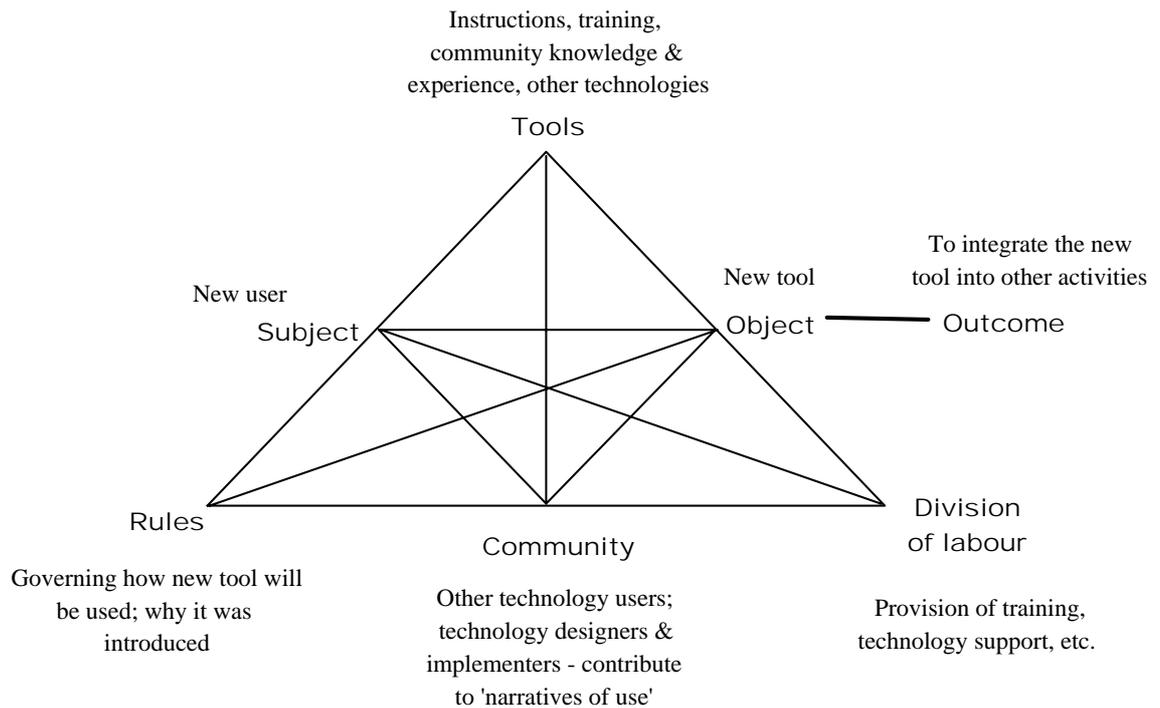


Figure 9-2. The ASTAM framework

The ASTAM framework is an analytical model that provides a way of categorising and describing the sociocultural factors that exert an influence over the way a new tool is appropriated. This model, then, differs from the technology appropriation framework that was developed by Jennie Carroll and colleagues (Carroll, Howard, Peck et al., 2002; Carroll, Howard, Vetere et al., 2002); their framework described the stages users go through when they encounter, evaluate, and choose to use a new technology. It also differs from DeSanctis and Poole's (1994) "adaptive structuration theory". Unlike DeSanctis and Poole's model, the ASTAM framework can be used to examine individual users' tool appropriation in any context, and is not limited to explaining how work groups adapt collaborative working tools for their own purposes. Furthermore, the ASTAM framework does not describe a series of stages; nor does it suggest that technology appropriation begins when the user first encounters the new tool. Rather, the ASTAM framework provides a way of looking

at the social setting in which a new tool is used – including the user’s past experience – and examining how that social setting has an effect on the way a new tool is appropriated. Each component in the ASTAM framework is discussed, in turn, below.

9.2.1. The subject

An important feature of any activity theory analysis is the recognition that activities are not static, discrete units: the history of the activity system is important for understanding the current state of that activity. Thus, in the tool appropriation activity, the user’s past experience with other tools and the history of tool use within that particular social setting, will be important influences over the tool appropriation activity. This was apparent in Case Studies A and B, particularly with reference to the way participants responded to the new limited text input methods on the PDA. The different experiences participants brought to the activity meant they differed in the way they felt about the PDA. This was clearly seen in the example of those who were experienced typists, who did not like using the handwriting recognition system. In contrast, those who did not like typing preferred the handwriting recognition systems on the PDA over other methods. Thus, as described above, participants varied greatly in the way they responded to and evaluated the PDA.

In Chapter 5 I also described how some participants had little time available to learn to use the PDA. This was linked to participants’ general inclination towards the PDA; those who felt positive about the PDA set aside time to learn to use the new tool and find ways of integrating it into their activities. Similarly, participants differed in their established work and study practices. For some, the PDA integrated

well with those practices, while for others the PDA did not support the way they preferred to work.

9.2.2. Mediating tools

When I examined the interview data, it appeared that the tool appropriation activity was greatly influenced by how well the PDA complemented or conflicted with the other technologies that participants used. The “mediating tools” node in the ASTAM framework was the most relevant place to represent these. The concept of mediating tools, however, might be better employed to describe those artefacts and tools that helped the user familiarise herself with the PDA. However, in this analysis, such tools were assimilated within other components of the activity system framework. For instance, the tool appropriation activity was *mediated by* the subject’s past experience. This, however, was discussed with reference to the subject node in the ASTAM framework. Similarly, community knowledge could be regarded as a mediating tool; however, I chose to analyse this aspect of the social setting with reference to the community node in the activity system. This underlines the point that was made in Chapter 3 that activity theory concepts are open to interpretation and there is no standard way of defining the categories in the activity system framework.

The other technologies that participants used included desktop or laptop computers, pen and paper-based tools, and (in Case Study A) printed reading materials. In some circumstances, the PDA clearly complemented these other technologies; for instance, when the PDA was used as an electronic diary, it could be easily synchronised with the desktop or laptop computer, providing a way for participants to access a portable version of their shared electronic diaries. Similarly, for some students in Case Study

A the PDA complemented, rather than conflicted with, the printed version of the course materials. Some participants said they made use of both versions of the course materials, electing to use the PDA in situations where the A4 printed documents were either unavailable or too large and obtrusive to use.

For some participants, however, the PDA did not offer any benefits over the other technologies that were used. For instance, many mobile workers in NGC were *active* mobile workers, in the sense that they had to produce a lot of information while working remotely. For these people, the laptop computer was an essential mobile working tool and the PDA was seen as redundant. That is, some of the people I spoke to felt they had no need for a PDA in addition to the other mobile technologies they used. Thus, this analysis reinforces one of the main findings of this research: that the social setting into which the PDA was introduced differed for each participant, and therefore the way the PDA was used varied greatly across each case study.

9.2.3. The community

The community in the tool appropriation activity consisted of participants' colleagues or fellow students, as well as the friends and family members who contributed knowledge and experience about how to use the PDA. Thus, each participant belonged to their own unique tool appropriation community.

The contribution of the community to this activity was most apparent with respect to the relevant knowledge and experience that community members provided. For instance, some community members offered technical expertise which was helpful in overcoming the technical difficulties that users encountered. Some members of the

community had previously used PDAs; their experiences were assimilated by the new users who in many cases appeared to base their expectations and understanding of the PDA upon what they knew about their friends' and colleagues' past experiences.

Thus, there was evidence in these case studies of the existence of what Churchill and Wakeford (2002) termed "narratives of use." This was particularly apparent in Case Study C, where those responsible for technology provision in NGC had created a "discourse of mobility" which conveyed to staff how they believed PDAs should be used in order for people to get "best value" out of the devices. It appears, then, that narratives of use and the experiences of other members of the community are important in determining how new tools come to be appropriated in particular social settings. The community contributes to the user's understanding of the technology. That is, community knowledge is important when users establish the technological frames (Orlikowski & Gash, 1994) or conceptual properties of an artefact (Cole, 1996) that guide how they appropriate the new tool.

9.2.4. Rules and division of labour

There was less evidence in these case studies of how the rules and division of labour in the ASTAM framework affected the tool appropriation activity. This raises questions about the utility of the activity system model for understanding the tool appropriation process: of the three additional components in Engeström's (1987) expanded activity system triangle, only the "community" component proved to be particularly useful and relevant in understanding the process of tool appropriation in this research. Rules and division of labour are notoriously difficult to interpret in activity theory analyses. They can include implicit ways of doing things, which may

not be easily conceptualised or observed in a research setting. Halloran (2000) also encountered this difficulty; he removed these nodes from his rather complex Activity Space framework (a reinterpretation of the activity system model that is designed to represent multiple interconnected activities - see also Halloran et al., 2002).

Nevertheless, there were some instances in the present research where the rules and division of labour appeared to be important. For example, as described in Chapter 5, the rules governing the provision of technical support in IET (Case Study B) were related to the division of labour in the activity system; there were some members of the community whose role was to help overcome technical difficulties when they occurred. However, these community members were also involved in other activities, providing technical support to the entire department. This led to a contradiction between the tool appropriation activity and the technical support activity; resources were therefore sometimes unavailable when participants wanted help in overcoming technical difficulties with the PDA.

9.2.5. The object

The tool itself – the object towards which the activity was directed – presented new possibilities and constraints. These had an effect on the way the PDA was appropriated. For instance, battery life limitations meant that some participants had to modify the way they used the PDA in order to avoid having to constantly replace or recharge batteries. Meanwhile, as already discussed, some participants modified the way they used the PDA in order to overcome the text input limitations.

In contrast, the possibilities of the PDA – primarily, its portability – gave participants the opportunity to enhance their learning and work activities. The PDA provided a

means of storing information in electronic format in a small, lightweight device that could fit in the palm of one's hand. Furthermore, the PDA could be easily synchronised with the desktop or laptop computer. These properties made the PDA a truly personal device, as discussed further below.

9.2.6. Outcome

One interesting outcome of the tool appropriation activity, as described in Chapter 5, is that participants who successfully integrated the PDA into their activities appeared to become emotionally dependent on it, or at least described it in anthropomorphic terms. They referred to the PDA as a "friend," and stressed that they could not bear to be parted from it. This supports Christiansen's (1996) argument that when new tools become integrated into users' activities, users come to "care for" and "cultivate" those tools. Christiansen made this declaration with reference to a series of interviews she conducted with Danish police officers who were in the process of integrating new computer systems into their work. Christiansen observed that those officers who had used the computer system successfully were particularly attached to the new tool.

It would be interesting to ascertain how this feeling of attachment relates to the properties of an artefact. Mobile technologies, being portable and therefore highly personal, appear to be particularly conducive to a feeling of emotional dependence. Vincent (2003) noted this with reference to mobile telephones. She argued that many users appear to have an emotional attachment to their mobile phones, which can be partly explained by the omnipresence of the technology. Mobile phones are omnipresent both in terms of their pervasion in society and in the sense that they are always available to the user. Vincent argued that when the mobile phone becomes

unavailable – for instance, when it must be switched off in certain social settings – then the user may experience panic, resulting from the separation from the device and the social contact it provides.

Of course, this dependence may be more pronounced in mobile phone users, as the mobile phone provides the user with the possibility of being in constant communication with other people. Nevertheless, a similar effect seemed to occur in the first two case studies in this thesis. Participants said they felt “lost” without the PDA, and once they became dependent on it they had to be extra careful about recharging batteries and backing up data to the desktop computer; they felt that the consequences of losing data would be catastrophic. Similarly, Harper (2002) described the attachment a colleague said he felt towards his PDA: “One recent American visitor at my research establishment commented that he was struck by the absence of people using PalmPilots in meetings in the UK. ‘I couldn't do without mine,’ he said, ‘I would feel completely at a loss’” (p. 214).

This feeling of being lost without the device could be related to the properties of the PDA, also known as affordances (Norman, 1998). Affordances are “those fundamental properties that determine just how the thing [an artefact] could possibly be used” (Norman, 1998, p.9). The PDA affords emotional attachment by being constantly available (depending, of course, upon how the user has appropriated it). For some users, the portability of the PDA means that it can always be carried on the user’s person, either in a shirt pocket or handbag. Thus, it is a truly personal device.

Of course, the PDA was not the only personal and portable technology that participants used. Interestingly, one student in Case Study A also cited an emotional attachment to his favourite pen. In the following posting to the FirstClass conference he described, tongue-in-cheek, how he felt when the pen “died.” Like Christiansen (1996), he used the analogy of having to “care” for the new tool:

Last month, the Sheaffer pen that my mum gave to me to sit my finals three decades ago finally gave up the ghost when its snorkel dropped off. I have mourned soundlessly since then, but now it is time to come to terms with my grief. Sheaff, faithful soul, clearly had a premonition and chose death above redundancy. I shall say goodbye to inky fingers and grasp my Personal Digital Assistant with soapy enthusiasm. Clearly, though, she/he/it? will need far more care and attention than old Sheaff. I would be grateful ... if you could advise me in words made up of recognisable syllables how she/he/it? should be fed and watered. (Case Study A, FirstClass contribution)

Much as the student quoted above felt that his favourite pen was an inherent part of his life, some participants in this research also appeared to feel this way about their PDA, suggesting that they had successfully integrated the PDA into their learning or work activities. Thus, it appears that one consequence of the tool appropriation activity is that users become dependent on the new tool. Another consequence, described below, is that the new tool changes the activities it is used to support. This is what I have described as tool mediation.

9.3. TOOL MEDIATION

In this thesis, the term tool mediation refers not only to how an objective is achieved through the use of tools, but also to how new tools change activities. It was this aspect of tool mediation that formed the focus of my analyses. I addressed the question of how PDAs mediate learning and workplace activities with respect to Case Studies A and B, and – to a lesser extent – the final observation study

conducted at the Tate Modern. Given the small scale of this study, however, I am limited in the conclusions I can draw from it.

Each of these studies would have benefited from an in-depth analysis of the activity system prior to the introduction of the PDA. Instead, my understanding of how the PDA changed the activities it was used to support is based on interviewee accounts of this change process. Observations of the activities before and after the PDA was introduced could have provided a richer account of the PDA's impact. Nevertheless, in many cases interviewees were quite articulate about how they used the PDA and how it changed their activities. This was one of the advantages of conducting the first two case studies in settings where participants were familiar with the concerns of this research. In Case Study A, participants were themselves studying the effects of new technologies on learning activities, while this was also the professional interest of participants in Case Study B. Thus, in both studies, participants were aware of issues surrounding the use of new technologies and were able to reflect on their own experiences in perhaps a more coherent way than might otherwise have been possible.

Activity theory concepts were applied to this analysis in three main ways. Firstly, I used the concept of contradictions in the activity system to describe how the PDA both introduced and resolved contradictions in the activities it was used to support. Secondly, the vertical division of activities into hierarchical layers of actions and operations, and the concept of breakdowns in those processes, were used to describe the impact of the PDA at the procedural level. Thirdly, I also examined how the

PDA had an impact on the overall activity systems into which it was introduced. Each of these is described further below, followed by a review of the TIP model.

9.3.1. Contradictions

The PDA both introduced and resolved contradictions in the activities it was used to support. In the reading activity of Case Study A, for instance, the portability of the PDA resolved a contradiction between the rules and the tools of the activity. That is, the informal regulations of Open University study suggest that students must make use of every little bit of spare time they can (Jones et al., 1992). However, many of the tools used – for instance, A4 size folders and desktop computers – were not conducive to this rule. Meanwhile, the PDA introduced some contradictions. For instance, the PDA did not support some of the students' established reading strategies – such as skim-reading, annotating text or drawing diagrammatic notes.

In Case Study B, too, the PDA resolved contradictions through its portability. For instance, it overcame limitations of paper diaries, which could not be easily synchronised with the Outlook calendar, and made it possible to download the email in-box, thereby enabling participants to manage their emails while away from their desks. In this case, again, there had been a contradiction between the rules of the activity system – that email was the primary means of communicating and sharing information – and the tools, which typically involved desktop computers that confined activity to the office or home environment. Thus, the affordance of the PDA in terms of its portability appeared, for some participants, to have a positive effect on the activity.

It appears, then, that the PDA had the most impact on *secondary contradictions* in the users' activity systems. As discussed in Chapter 3 (Section 3.3.4), secondary contradictions were defined by Engestrom (1987) as conflict between two or more components in an activity system. In the examples outlined above, there were conflicts between the tools and the rules of participants' activity systems, which in many cases were resolved by the PDA. It is unsurprising that the PDA had the most effect on this type of contradiction. As Engestrom (1993) argued, secondary contradictions are the driving force behind change and development in an activity system. Thus, it could be assumed that the introduction and resolution of secondary contradictions in an activity system would have a catalytic effect on other aspects of the activity.

9.3.2. Actions, operations and breakdowns

The PDA had the most disruptive effect on the actions and operations of the activities. As described in Chapter 3, actions and operations are the procedures through which the objectives of an activity are realised. In some cases, the PDA caused breakdowns in the activity: situations where the user could no longer apply the operations (routine processes) at his disposal (Bodker, 1991). In Chapter 6, I cited the example of one participant in Case Study B who had not yet learned how to write the Graffiti handwriting characters on the PDA. When he tried to enter text into the PDA, then, the PDA did not recognise the characters he was writing and he eventually gave up in frustration. A similar breakdown occurred in the Tate Modern study when I tried to scroll through the list of names of possible text message recipients. The PDA did not recognise this action and so a technical breakdown occurred; the screen froze and I had to resolve this breakdown before I could resume the activity.

Similarly, many participants described instances where they were unable to use familiar operations and had to develop new tool-oriented actions. That is, they could no longer focus on the goal of the activity and instead had to focus on the tool itself – the PDA. This was particularly the case, again, with respect to text input methods. Participants found that in order to take notes during meetings, for example, or to record an appointment in the diary, they had to concentrate on writing each individual letter, a more time-consuming process than the operationalised procedures of writing with a pen or typing on a full-size keyboard. Conversely, the participant in Case Study B who primarily used her PDA in combination with the foldout keyboard found that she was able to utilise her operationalised touch-typing skills, which enhanced her note-taking activities.

9.3.3. Activity systems

The ASTAM framework described above depicts the tool appropriation activity system where the PDA is the object of the activity. The intended outcome of this activity system is that the new tool – the PDA – becomes integrated into the user's other activity systems. Thus, the PDA is both the object of the tool appropriation activity, and a mediating tool in other activity systems. With regard to its role as a mediating tool in the activities it was used to support, the PDA clearly modified those activities in various ways. We have already seen how the PDA resolved some contradictions and introduced others, and how the PDA had an effect on the actions and operations that make up activities. In addition, there were some instances where the PDA appeared to have a modifying effect on other elements of the activity system. For instance, in Case Study B the PDA was the catalyst for some participants to begin using an electronic diary that could be shared with colleagues.

This had an effect on the division of labour in the activity system. Keeping a diary on the central server meant that the time management activity could be more effectively shared with secretaries and other colleagues. This reduced and modified the actions that the central actor had to undertake. For instance, some academics shifted the responsibility for arranging meetings to their secretaries, who could check availability and enter appointments directly into the academics' diaries, without having to consult with them first. For some participants (e.g., B06, B11) this resulted in a more efficient activity system.

9.3.4. The TIP model

In Chapter 6, I used the analysis of tool mediation to develop a model describing the *Tool Integration Process* (the TIP model). This model, reproduced below in Figure 9-3, draws on the analyses described above and illustrates how the data from Case Studies A and B describe the process through which the PDAs mediated the activities they were used to support. This model draws on both the task-artefact cycle by Carroll et al (1991), and the activity theory concepts that were used in this analysis. The new tool is shown to introduce new possibilities and constraints to the activity. The possibilities of the new tool resolve contradictions in the activity system. As described above, this was most apparent in this research with respect to the portability of the PDA and the resolution of contradictions between the rules and tools in the existing activity systems.

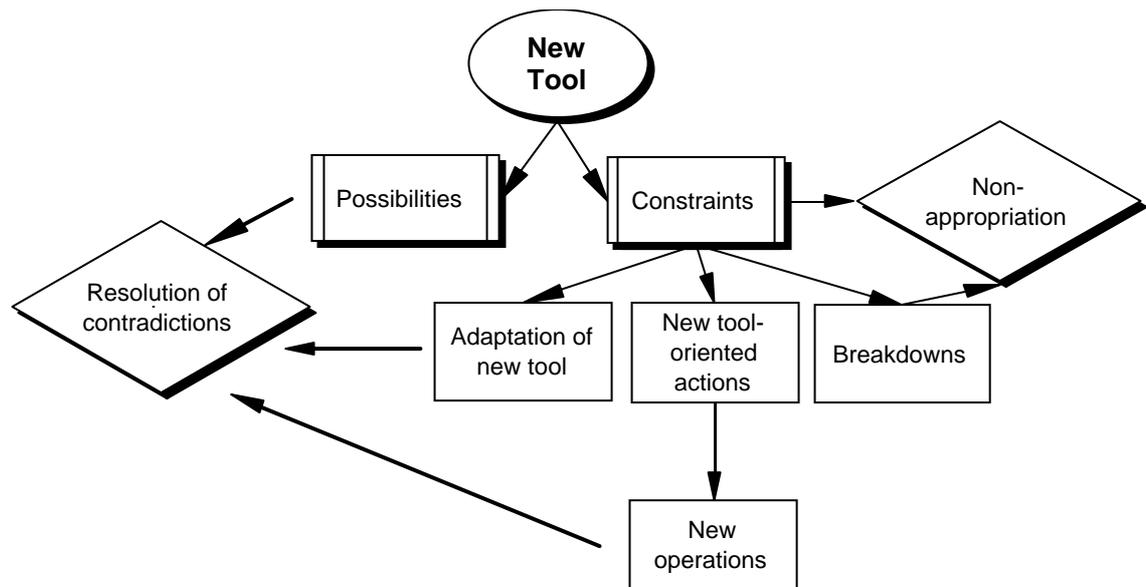


Figure 9-3. The TIP model

The constraints that a new tool introduces can be linked to Bodker's (1991) notion of operations that become conceptualised – or raised to the level of conscious awareness – when new tools are used. That is, many of the routine processes that users have developed from past experience with other more familiar tools, may no longer apply. This can result in one of four outcomes:

- 1) The user may choose not to appropriate the new tool.
- 2) The user may adapt the new tool in order to overcome its limitations.
- 3) The user may need to develop new tool-oriented actions; that is, focus on the tool itself while developing new operations.
- 4) There may be breakdowns in the activity. This may also lead to non-appropriation.

As described in Chapter 6, each of these outcomes occurred in Case Studies A and B. There was also some evidence of these effects in the Tate Modern study, particularly in relation to breakdowns in the activity. However, in that study these were primarily due to technical breakdowns in the tool itself, an expected occurrence when

a new technology is being tested and undergoing formative evaluation, as was the situation for that study.

Together, the ASTAM framework and the TIP model describe the two-way process of tool appropriation and tool mediation. That is, the ASTAM framework illustrates how the elements of a social system can have an effect on the way new tools are appropriated. Meanwhile, the TIP model describes how new tools change the activities they are used to support, through the introduction of both new possibilities and constraints. The concepts of tool appropriation and tool mediation are linked to the more general idea that technologies and social systems are engaged in a continual process of “reciprocal shaping” (Brosveet & Sorensen, 2000). In this thesis, I examined this two-way process with reference to a particular example of a mobile technology – the PDA – and looked at how it was used in specific social settings. Activity theory provided a useful way of defining and identifying these social systems and examining the mediating effect of the PDA. However, as with any theoretical framework, there were both benefits and limitations of this theoretical approach. These are discussed further in the following chapter.

9.4. CONCLUSION

This chapter has provided an overview of the main findings from the research presented in this thesis. The chapter began with a discussion of how the PDA was perceived and used in the learning and workplace settings that were the focus of the four studies. One of the most salient findings of the evaluation was that participants reacted differently to the possibilities and constraints that the PDA introduced. Some participants felt the PDA enhanced their activities, while others found the PDA too

difficult or limiting to use. There were also some cases where people were initially enthusiastic about the PDA but over time found that its limitations outweighed its benefits, or their activities changed and the PDA was no longer considered a useful tool.

This evaluation focused upon the concepts of tool appropriation and tool mediation. The case studies therefore contributed to an empirically-grounded understanding of these related concepts. Tool appropriation was analysed using the ASTAM framework, which provided a way of examining how the sociocultural setting affects the way new tools are appropriated. The analysis of tool mediation, meanwhile, led to the development of the TIP model, described in Chapter 6, which illustrates how the PDA had an effect on the activities it was used to support in Case Studies A and B. Taken together, the ASTAM framework and the TIP model represent the two-way process of tool appropriation and tool mediation.

The following chapter completes this review with a final summary of the main contributions of the thesis, a discussion of the limitations of the research, and an overview of possible directions for future research.

Chapter 10

Conclusion

This chapter concludes the thesis with an overview of its main contributions, a discussion of its limitations, and a summary of the issues raised that are worthy of further investigation.

10.1. THESIS CONTRIBUTIONS

This thesis set out to answer the following research questions:

1. How are PDAs appropriated as learning and workplace tools?
2. How do PDAs mediate learning and workplace activities?

These questions have been addressed through the development of the ASTAM framework and the TIP model, which were summarised in the previous chapter and are revisited below, in Section 10.1.1.

Furthermore, as stated in the Introduction, this thesis contributes to a set of related research fields that are concerned with understanding and improving the way people use new technologies. These include HCI, CSCW, educational technology, and information systems. A central concern of these fields is to ascertain how new technologies can be used effectively in education and workplace settings. The thesis also draws on, and contributes to, the literature that aims to understand the reciprocal

shaping of technologies and society, which is likened here to the two-way process of tool appropriation and tool mediation. The following discussion examines three main contributions that this thesis makes to these related research fields.

10.1.1. A novel use of activity theory

This thesis is of particular relevance to the growing band of HCI researchers who are finding ways of using activity theory in evaluative and systems design research. One of the main contributions of the thesis to this field is in the novel use of activity theory as an analytical framework for examining the concepts of tool appropriation and tool mediation. There has been much interest in the past decade in the use of activity theory in HCI research (e.g., Kaptelinin, 1996a; Nardi, 1996a). Activity theory provides a way of examining the context in which new tools are used, broadening the scope of analysis beyond an isolated user interacting with a computer. Activity theory has primarily been incorporated into the systems design strand of HCI research, which is concerned with identifying requirements for the development of useful and usable computer systems (Mwanza, 2002). In this respect, activity theory has been used to determine contradictions that could be resolved by new technologies (e.g., Turner & Turner, 2001), and to evaluate the current state of particular activities so as to suggest directions for future technology development (e.g., Macaulay et al., 2000).

In contrast, the case studies described in this thesis were summative evaluations; that is, they focused on a technology that had already been developed, and examined how it was used in real-world settings. Activity theory was useful in this research in two respects. Firstly, it provided a way of examining the social setting in which the PDA

was used. Secondly, it helped describe how the PDA mediated the activities it was used to support, thereby helping to answer both the research questions of the thesis.

Drawing on Engeström's (1987) activity system framework, I developed the *Activity System Tool Appropriation Model* (ASTAM), which was a useful analytical framework for exploring the reasons why participants varied so greatly in the way they used the PDA. The ASTAM framework emphasises that there are multiple interacting elements at play in any particular activity. It suggests that appropriating a new tool can itself be described as an activity system, and this helps to understand why no two users are exactly alike; each participant in this research used the PDA in a unique social setting. In other words, the ASTAM analysis in this thesis has demonstrated that tool appropriation is both an individual activity as well as being socially situated. Recognition of this could help other evaluation studies examine why new technologies are often not used as expected.

For instance, Halloran, Rogers and Scaife (2002), whose study was reviewed in Chapter 3, examined the "failure" of students to use Lotus Notes in a collaborative learning activity in the way that tutors had anticipated. Halloran et al used activity theory to examine why Lotus Notes had not been used as expected. Their analysis focused on representing the conflict between the two central user groups: the tutors and students. They experienced difficulty, however, in representing these groups in one activity system model. Using the activity system framework to describe the collaborative learning activity, they were unable to represent the multiple interacting factors that appeared to contribute to the non-use of Lotus Notes.

According to the argument presented in this thesis, the analysis by Halloran et al (2002) might have benefited from recognition that (a) new tools are appropriated in unique ways by their users, (b) tool appropriation is an activity in itself, and (c) each user occupies his or her own space in the tool appropriation activity. In other words, the tool appropriation activity is different for each user. The ASTAM framework developed in this thesis, then, could have helped explain why individual students did not use the Lotus Notes tool as expected. Therefore, the ASTAM framework could be a useful analytical tool for future research that aims to understand how and why people have appropriated new technologies in particular ways.

In this thesis, activity theory also provided a way of describing how the PDA mediated the activities it was used to support. The concept of contradictions within activity systems and the vertical division of activities into actions and operations were particularly useful in this respect. An analysis based on these concepts led to the development of the *Tool Integration Process (TIP) model*. This model could be useful as an analytical framework for future end user evaluation studies. Each of the components in the TIP model could be used to guide data collection and analysis. This would encourage researchers to identify breakdowns, examine how users have adapted the tool in order to overcome its limitations, and pinpoint the existence of new tool-oriented actions. This would help determine how a new tool disrupts the activities it is used to support. Furthermore, identifying how the new tool resolves contradictions in an activity system would help researchers recognise how that tool enhances the activities it is used to support. Understanding how new technologies both disrupt and enhance activities is particularly important for workplace and educational technology studies.

10.1.2. An examination of the PDA as a learning and workplace tool

This thesis has examined the use of a mobile technology – the PDA – as a learning and workplace tool. As reviewed in Chapter 2, there is currently a growing literature exploring the potential use of mobile technologies in learning and workplace settings. Such literature, however, can sometimes contain a “pro-innovation bias,” suggesting that mobile technologies are unproblematic and invariably valuable tools (Rogers, 1995). In the research presented in this thesis I endeavoured to avoid this bias by acknowledging both the benefits and limitations of the PDA as it was used in each case study.

A salient finding of this research is that participants varied greatly in the way they responded to, and used, the PDA. One of the advantages of conducting four smaller case studies, and using interviews as the main form of data collection, is that I was able to evaluate the PDA from the perspective of each person who took part in the research. This included people who were enthusiastic about the PDA and used it extensively in their work or learning activities. It also included people who did not use the PDA, and those who discovered that over time, the PDA no longer served their needs as well as it had originally done. Thus, I was able to paint a rich and varied picture of how the PDA had been used across each of the case study settings.

One of the implications of this finding is that researchers and technology providers need to appreciate that users will appropriate new technologies in their own ways. This suggests that use of new technologies cannot be prescribed, and evaluations should not be based on predefined notions of how particular tools should be used.

Rather, it is important to recognise that new tools may become appropriated in unique ways by individual users; there is no “right” or “wrong” way to use a personal technology such as the PDA.

This evaluation has also provided some insights about how people use, and feel about, mobile technologies; these could be useful for informing future design and implementation decisions. One limitation of the research, however, is that it focused on a technology that was already widely available and did not incorporate many of the features that are currently being developed and deployed in mobile technologies. For instance, the PDAs used in the three main case studies did not have wireless communication capabilities. Much of the recent research exploring the use of mobile technologies in education and work has focused on the use of wireless networks to facilitate collaboration (e.g., Curtis et al., 2002; Sharples, Corlett et al., 2002). Other recent advances include the use of context-aware systems, where the content and format of information displayed on a mobile device is automatically tailored to the user’s location. This could be particularly valuable in museum learning settings (Hsi, 2003). However, as discussed in Chapter 1, developments such as wireless networking with PDAs were still in their infancy when this project began. The research therefore focused on the basic PDA, an already well-established and commercially available tool.

Despite the rapid rate at which mobile technologies are developing, the insights gleaned from this research are nevertheless relevant for the design and implementation of future mobile technologies. Most notably, in the case studies in this thesis the PDA was not seen to replace other technologies, but was used

alongside them. It was important, therefore, that the PDA was compatible with existing tools. One of the main perceived benefits of the PDA was that it could be easily synchronised with the user's desktop or laptop computer. However, some participants in Case Study C found it awkward to keep the PDA synchronised with a laptop computer while travelling, as this involved carrying additional cables. Synchronisation, then, was only straightforward for the user who was frequently at her desk and could use a fixed synchronisation cradle that did not need to be transported and reattached every time the user wished to transfer data between the PDA and the computer. This suggests that an important requirement for mobile technologies is that they can fit into a suite of technologies, allowing for seamless interaction between the different tools that people use.

It is important, therefore, that those responsible for designing and implementing new mobile technologies take into account the capabilities of the technical systems people currently use, and design new technologies that can easily merge with existing tools. However, ensuring compatibility between devices may be problematic in some situations, such as the distance education setting of Case Study A. In that study, students came from diverse backgrounds and had access to different technologies in their work and home settings. Therefore, providing a specific device that would be compatible with all students' existing technologies could be difficult. Indeed, I encountered this difficulty when designing Case Study A. Some students used Macintosh computers, and additional cables had to be purchased so that the PDAs supplied could be synchronised with their computers. The challenge in such a situation, then, is to ensure that any decisions about the provision or support of new technologies allows for flexibility, taking into account the needs of individual users.

A further important insight from this research is that users appeared to respond differently to the limitations of the PDA. Some found that the limitations outweighed the benefits, and so they preferred not to use the PDA. Others were indifferent to the limitations, while some participants managed to find ways of working around the constraints of the device.

Mobile technologies will always be beset with usability problems, such as small screens and limited text input methods. However, as the research in this thesis demonstrates, some users will persevere and appropriate the technologies in order to overcome these limitations. A further example to illustrate this is the popularity of text messaging among mobile phone users. Mobile phones were not designed for this purpose, and constructing text messages on a mobile phone was originally a slow and awkward process of tapping out individual letters on a small keypad. Despite the limitations, however, many mobile phone users – particularly teenagers – persevered and chose to use their phones primarily for this purpose (Reid & Reid, 2003). This raises questions about the importance of usability in technology evaluation research. Studies that focus solely on usability will not be particularly informative about how people actually use, and respond to, the technology being evaluated. The concept of tool appropriation, then, should be an important part of technology design and evaluation studies. As Carroll (2004) stated, understanding how people appropriate technologies could be helpful in identifying requirements for future technology designs. This can be demonstrated by the text messaging example: following the popularity of text messaging, mobile phones were soon enhanced by features designed to support text messaging, such as predictive text input and larger foldout

keypads. In other words, users' appropriations of the mobile phone drove further technology developments.

10.1.3. The two-way process of tool appropriation and tool mediation

By focusing on tool appropriation and tool mediation, this thesis contributes to an understanding of the reciprocal shaping of technology and society. The idea that a two-way process occurs when new technologies are integrated into activities is not new. However, much of the literature on the social shaping of technologies is concerned with quite substantive issues, and has traditionally sought to describe the social shaping of technology design and development, rather than technology appropriation (Mackay, 1995). For instance, the essays included in MacKenzie and Wajcman's (1985) collection looked at how gender and socioeconomic issues have been embodied in technology designs. Elsewhere, researchers have examined how social factors affect technology use in third world countries (e.g., Akrich, 1992; Suchman, 2002), and how new technologies become domesticated at a national level (e.g., Brosveet & Sorensen, 2000).

The research presented in this thesis, in contrast, describes particular instances of new technology use. Through the evaluation of the PDA as a learning and workplace tool I have developed an empirically-grounded understanding of the related concepts of tool appropriation and tool mediation. Thus, I have contributed to the social shaping literature an in-depth examination of how PDAs both were appropriated by users and mediated the activities they were used to support. This is in line with Harper's (2002) suggestion that research on the social shaping of technologies should focus on specific instances of technology use:

When properly used the term [social shaping] is a label for the fact – and indeed it is a fact – that people and technology shape each other. ... What one should try and do is explore how, in any particular historical instance, the form and balance of factors that constitutes social shaping manifests itself. (Harper, 2002, p.223)

Departing from the more sociological research that occupies much of this field, I did not examine the wider societal and cultural influences over the way PDAs have been designed and adopted across broad social groups. Rather, the focus on specific case study settings and the use of interviews as the main source of data enabled me to look at how the use of PDAs was socially shaped in individual cases. Furthermore, activity theory provided a way of identifying and describing the reciprocal shaping that occurred in each study. Applying activity theory to the data helped to clarify the concepts of tool appropriation and tool mediation, emphasising that these dual concepts are closely related. Therefore, future evaluation studies need to take into account the idea that while new technologies change the activities they are used to support, the way new technologies are used – and therefore the sorts of changes they incite – can be greatly influenced by the social setting in which the technology is used. In other words, the concepts of tool appropriation and tool mediation cannot be divorced.

10.2. REFLECTIONS ON THE CHOICE OF THEORY AND METHODS

In this section, I will outline some of the limitations of the research, reflecting on the choice of theory and methods that guided the research.

10.2.1. Activity theory

The choice to use activity theory as an analytical framework both enriched and constrained the research. Some of the constraints of activity theory have been well documented. For instance, it is widely acknowledged that although activity theory stresses that all activities are in a constant state of development and transformation, the activity system framework does not provide a way of representing how these developments take place over time (Mwanza, 2002). However, the concept of contradictions provides a way of describing particular aspects of activity system development, going some way towards addressing this problem.

A further widely recognised concern is that activity theory consists of a broad set of concepts that are open to interpretation (Engestrom, 1993). This offers both advantages and disadvantages. The flexibility of activity theory means it can be used in many different ways by researchers working in a range of research settings. This can lead both to recognition of the potential richness and explanatory power of activity theory, and to conflict among researchers about the “correct” way of using activity theory.

In this thesis, I have presented my own interpretation of activity theory and used it in a unique way to analyse the processes of tool appropriation and tool mediation. My interpretation of activity theory may be viewed by some as an incorrect use of activity theory. In particular, in the ASTAM framework I used the activity system model to describe tool appropriation as an activity in itself where the object of the activity is the tool being appropriated. This suggests that tools can have dual status as both the mediators of activity and as objects of certain activities. This point was

also acknowledged by Bodker (1996) and hinted at by Kuutti (1991). Thus, my use of activity theory here is consistent with other activity theorists' ideas.

Furthermore, as discussed in Chapter 3, activity theory is not a theory as such; it does not aim to predict phenomena, and its claims cannot be proven or disproved. Rather, it provides a way of looking at the world, a vocabulary for describing the social settings in which activities take place. As Nardi (1996a) highlighted, activity theory is a “powerful and clarifying descriptive tool rather than a strongly predictive theory” (p.7).

As such, the ASTAM framework developed in this thesis is a descriptive tool, helping to capture the idea that the way people use new technologies is intricately tied to the social setting in which that tool is used. Features of the social setting – such as the characteristics of the user, the community, rules, and division of labour – all have an influence over the way a new tool is appropriated. This certainly appeared to be the case with regard to how the PDA was used in each of the case studies described in this thesis. Case Studies A and B were especially informative about the tool appropriation activity system, as described in Chapter 5.

Similarly, the TIP model developed in Chapter 6 is a descriptive, rather than predictive, framework. Taken together, the ASTAM framework and the TIP model represent the two-way process of tool appropriation and tool mediation. However, linking these two frameworks is not straightforward because they each draw on, and describe, different concepts from activity theory. While the ASTAM framework describes tool appropriation as an activity system, drawing on Engeström's (1987)

activity system triangle, the TIP model describes the impact of a new tool in terms of its effect on the actions and operations that make up an activity. The TIP model does not describe the effect a new tool has on the activity system, except through the resolution of contradictions. It does not specify how a new tool changes the subject, community, rules, or division of labour that make up an activity. Rather, it describes the **process** through which a new tool changes the activities it is used to support.

One reason for this is that, as stated above, the TIP and ASTAM models are descriptive rather than predictive. It would be impossible to develop a generic predictive model that specifies how a new tool will change the different components in an activity system. Each tool will bring to an activity its own set of possibilities and constraints, and each activity system will be unique. Therefore, a generic model cannot explain the effect a particular tool will have on a particular activity system. Rather, the TIP model helps to explain **how** new tools change activities: by introducing new possibilities and constraints, which in turn have an effect on the contradictions in the activity system and the actions and operations that make up the activity. As described above, this model could be useful for directing future evaluation studies that aim to understand the impact new tools have on particular settings.

The use of different activity theory concepts in the TIP and ASTAM frameworks highlights one of the general limitations of activity theory: because it consists of a broad set of concepts that have been drawn from various sources, the links between these concepts are not always explicit. In particular, there are no explicit links between Engestom's (1987) activity system framework and Leont'ev's (1978) and

Bodker's (1991) ideas about actions/operations and breakdowns. Further attempts to link these concepts could be helpful in extending activity theory and developing its value as an analytical framework for technology design and evaluation research.

10.2.2. Practical limitations

The selection of methods used in this research was guided not only by my choice of activity theory as an analytical framework, as discussed in Chapter 4, but also, inevitably, by practical issues. In the previous chapter, I acknowledged that it would have been beneficial to have conducted more in-depth observations of the activity systems under analysis, particularly with regard to how these activity systems operated both before and after the PDA was introduced. However, I did not have the opportunity to conduct a thorough examination of any of the case study settings **before** the PDA was introduced. Rather, the studies focused on how the activity systems developed **after** the PDAs were introduced.

Furthermore, the use of additional observation methods could have helped overcome some of the limitations of relying primarily on self-report methods. For instance, participants' accounts of how they used the PDA may not have always been accurate; they may have forgotten or neglected to mention certain details, or exaggerated some issues. Furthermore, it is widely acknowledged that interview studies are prone to self-report bias (Wilson, 1996). In other words, participants may respond to questions by saying what they believe the interviewer wants to hear. In my studies, this may have led to an overly positive or negative evaluation of the PDA. However, this did not appear to be the case. The mixed responses to the PDA suggest that, overall, participants were open in their reflections about how they used and felt about the PDA. One possible reason for this is that, particularly in Case Studies A and B,

participants were familiar with the process of researching and evaluating the use of new technologies. As such, they were used to considering both the positive and negative aspects of computer tools.

The choice of particular research settings, then, can both constrain and enhance the research. Case Studies A and B both took place in settings where participants were familiar with the processes and purposes of educational technology research; they were therefore particularly articulate and forthcoming in their discussions of the PDA. However, because these participants were educational technology researchers and students, they may have been particularly receptive towards, and enthusiastic about, new technologies. This could have biased the research towards an overly positive evaluation of the PDA. This certainly appeared to be the case with regard to the follow-up interviews in Case Study A: those students who volunteered to take part in the follow-up interviews were, with one exception, all enthusiastic PDA users. These interviews were nevertheless valuable in providing further information about how sociocultural factors influenced the process of tool appropriation, as reported in Chapter 5.

Access issues also constrained the research that was carried out for Case Study C. This study took place in a large international organisation in the gas exploration industry (NGC). This setting, therefore, was quite different from that of the first two studies; participants in this study were not so familiar with the research process and may not have been so receptive towards the use of new technologies. Because of this, gaining access to this setting was sometimes difficult. I negotiated access to the organisation through two *gatekeepers*: key informants in the Information Technology

team who each took on the role of facilitating my research within the organisation. The first gatekeeper was very enthusiastic and supportive of the research. The second gatekeeper, however, was more sceptical and did not seem eager to support the project. Unsuccessful attempts to negotiate further access through this gatekeeper meant that I was unable to carry out a follow-up study examining how the new iPAQ PDAs – which replaced the Palms – had been received by employees at NGC. Such a study would have been valuable, as this was a particularly rich research setting in which to examine the implementation and use of mobile technologies.

Despite the constraint of access issues – an inevitable feature of social science research – the research carried out for this thesis produced a rich and varied data set exploring the use of PDAs in learning and workplace settings. This research has raised many issues that could provide avenues for future work, as outlined below.

10.3. FURTHER RESEARCH

Many of the issues raised in this thesis could benefit from further research. For instance, in the previous chapter I noted that one of the outcomes of the tool appropriation activity was that some users developed an emotional dependence upon the PDA. It would be interesting to examine how this feeling of emotional attachment relates to the properties of the tool being appropriated. I noted that the PDA is a highly personal tool; it is portable, contains personal information, and is not usually shared amongst users. Perhaps, then, these properties of the PDA contributed to the emotional attachment some participants appeared to have for the device. It remains to be seen whether such attachment could also be the outcome of other

instances of tool appropriation, involving tools that do not inspire a sense of personal ownership, such as collaborative working tools.

I also noted above that one of the limitations of this research is that I did not conduct an in-depth study of the activities from each case study before the PDA was introduced. Rather, I relied on interviews with participants after they had begun using the PDA in order to understand how it had changed their activities. Further research could therefore be helpful in extending the ideas of tool mediation presented here by examining activity systems before and after new tools are introduced. Such research could also benefit from the use of observation data, in addition to interviews and other self-report methods.

The concepts of tool appropriation and tool mediation that are presented here are based on my evaluations of the PDA. Further research is needed to ascertain how these concepts apply in other instances of new technology use. For instance, one of the implications of this study is that future research needs to take into account how people differ in the way they use new technologies, and to recognise that tool appropriation is not a “failing.” However, this point may only apply to personal and multipurpose technologies such as the PDA. Other technologies, such as the medical diagnostic tool described by Hasu and Engestrom (2000) (see Chapter 3), may not offer users the same flexibility as the PDA. However, the use of such technologies may still involve some element of appropriation. For instance, users may need to adapt the way they use the technology in order to overcome its limitations or to suit the particular circumstances in which it is used. Further research, then, could examine the importance and salience of tool appropriation in circumstances other

than the settings described in this thesis. In particular, the concept of tool appropriation could be examined in contexts where users are not given the same flexibility in the way they use the technology. This could help determine the importance of offering users control in the way they use new technologies, an issue that is relevant for both technology designers and for those responsible for implementing new technologies in learning and workplace settings.

Further research could also extend the activity theory frameworks that have been developed and used in this thesis, and test their utility as tools in other research settings. In this research, the ASTAM framework was a useful way of identifying and framing the sociocultural factors that appeared to influence the process of tool appropriation. As discussed above (Section 10.1.1), the ASTAM framework might also be useful as an analytical tool in other evaluation studies, particularly for researchers seeking to understand the reasons behind the variation in the way people use new technologies. For instance, the ASTAM framework might be useful for systems designers and educational technology researchers who wish to better understand the process of tool appropriation in order to make better-informed decisions about the design and implementation of new technologies.

However, further research is needed to test the utility of this model in other research settings. One of the main limitations of the ASTAM framework as a research tool is that the activity system model upon which it is based is quite complex, and therefore it may not be accessible to researchers unfamiliar with the underlying activity theory concepts. This is a widely-acknowledged problem with activity theory, and other researchers have attempted to devise methods designed to make activity theory more

accessible to systems designers and evaluators (Kaptelinin et al., 1999; Mwanza, 2002). However, some background knowledge of activity theory is still necessary in order to utilise these methods. Perhaps, then, a first step for future research would be to find ways of making the ASTAM framework more accessible.

A further limitation of the activity system model upon which the ASTAM framework is based, is that it is open to interpretation. This means there is some flexibility as to how the labels within the ASTAM framework can be used. This point was acknowledged in the previous chapter when I suggested that factors such as the subject's past experience and knowledge within the community might also be considered mediating tools in the tool appropriation activity. However, I chose to discuss these with reference to the "subject" and "community" nodes in the framework. Similarly, there was a problem in representing the existing tools that participants used, which were particularly important in the tool appropriation activity. As discussed above (Section 10.1.2), this research demonstrated that, for the PDA to be used successfully, it was important that it complemented, rather than conflicted with, existing technologies. Therefore it was essential in this analysis to not only capture elements of the social setting in which the PDA was used, but also to examine the technical system into which the PDA was being integrated. I chose to discuss the importance of the existing technologies with reference to the "mediating tools" node in the ASTAM framework, although existing technologies might not be, strictly speaking, mediating tools.

This raises questions about whether the ASTAM framework can be used to fully capture all the factors involved in tool appropriation. Other weaknesses of the model

include that it does not allow a full analysis of the context in which the new tool is used; for example, the physical setting, and the types of interactions that are involved in that setting (although these might be examined under the concept of “rules”). Therefore, further research could be conducted to extend this model and to determine whether there are other influences that have not been incorporated into the ASTAM framework. Furthermore, the concepts of rules and division of labour were not thoroughly examined in this thesis; future work could seek to further understand how these concepts influence the process of tool appropriation. In addition, the research presented in this thesis suggests that community knowledge and “narratives of use” are important in shaping how people feel about, and use, new technologies. Further understanding about the importance of these concepts could be useful for informing decisions about the implementation of new technologies in group settings.

In addition, as described above (Section 10.1.1), the TIP model developed in this thesis could be useful for guiding future data collection and analysis in technology evaluation studies. However, further work is needed to test the utility of this model as an analytical framework. Further work is also needed to explicate the links between the TIP model and the ASTAM framework, which each draw on different aspects of activity theory, as discussed above (see 10.2.1). Developing a better understanding of the links between these models would not only help to clarify the relationship between different activity theory concepts; it would also help further our understanding of the relationship between tool appropriation and tool mediation, thus developing the central theme of this thesis.

10.4. CONCLUSION

This thesis has examined the two-way process of tool mediation and tool appropriation, based on an evaluation of the use of PDAs as learning and workplace tools. This thesis makes three main contributions. Firstly, it contributes to the growing literature concerned with evaluating and exploring the use of mobile technologies in education and work, identifying both the possibilities and constraints that the PDA introduced in each of the case study settings. Secondly, this thesis presents a novel use of activity theory as an analytical framework for examining how new tools both mediate activities and are appropriated by individual users. Finally, this thesis has described an empirically-grounded understanding of the two-way process of tool appropriation and tool mediation. Each of these contributions could be useful for guiding future evaluation studies, and informing the design and implementation of new mobile technologies in learning and workplace settings.

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Appendix A

Case Study A – Pre-questionnaire

Evaluation questionnaire:

Using and navigating electronic course materials¹⁴

Part III. Set books

1. When you read text in the set books, do you . . .

Highlight or underline text?	<i>Never / Sometimes / Frequently</i>
Write notes in the books?	<i>Never / Sometimes / Frequently</i>
Write notes on a separate piece of paper?	<i>Never / Sometimes / Frequently</i>
Type notes on a computer?	<i>Never / Sometimes / Frequently</i>
Write notes on sticky post-it notes?	<i>Never / Sometimes / Frequently</i>

2. Are there any other things you do to support your study-related reading?

Part IV. Beliefs about the benefits and limitations of PDAs

You will soon be supplied with a Personal Digital Assistant (PDA), which is a handheld computing device that can be used for a variety of purposes, including for reading study texts. The following questions relate to your opinions about PDAs.

3. How useful do you believe the PDA will be for reading course materials?

1	2	3
Not useful	Somewhat useful	Very useful

4. Why do you believe the PDA will/will not be useful for reading course materials?

¹⁴ This questionnaire originally included 20 questions that elicited students' opinions about other aspects of the H802 course, such as the course website and FirstClass conference. These questions were for a general evaluation of the course carried out by the course team, and are not reproduced here.

5. In addition to reading course materials, in what other ways do you hope to be able to use the PDA to support your study activities?

6. Do you already use a PDA or handheld computer (e.g., Palm, Psion, Hewlett Packard Jornada)?

Yes / No

7. If so, what PDA do you use?

8. For how long have you been using it?

9. Do you use any accessories with your PDA (e.g., foldout keyboard, digital camera)?

10. If so, what accessories do you use?

11. Do you use the PDA to read pages of text?

12. Do you use the PDA primarily for . . ? (please tick all that apply)

Personal use
Work use
Study

Thank you for taking the time to complete this questionnaire.

Your participation is very much appreciated!

Appendix B

Case Study A – Post-questionnaire

Using the Palm m105 PDA

1. How often did you use the Palm m105 PDA?

(Please type 'X' in the appropriate box)

Less than once a week	
Once a week	
A few days a week	
Every day	
Did not use	

2. When did you use the Palm m105 PDA?

(Please select all that apply. Type 'X' in the boxes that apply.)

At home	
At work	
While commuting to/from work	
On long-distance travel	
While on holiday	
Other (please specify)	

3. How often did you use the Palm m105 PDA to read course materials?

(Please type X in the appropriate box)

Less than once a week	
Once a week	
A few days a week	
Every day	
Did not use	

4. What other functions of the Palm m105 did you use?

(Please select all that apply. Type X in the appropriate boxes)

Diary	
Address book	
To-do list	
Notes	
Memo pad	

Calculator	
Games	
Other (please specify)	

Reading course materials on the Palm m105 PDA

The following questions are about how easy or difficult it is to read course materials on the Palm m105

- 5. How easy/difficult was it to read course materials on the Palm m105?**
(Please type X in the appropriate box)

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	
Did not read course materials on the Palm m105	

- 6. Why was it easy to read course materials on the Palm m105?**

- 7. Why was it difficult to read course materials on the Palm m105?**

- 8. For how long can you comfortably read from the screen of the Palm m105?**
(Please type X in the appropriate box)

A few minutes	
Up to half an hour	
Up to an hour	
More than an hour	

- 9. When reading course materials on the Palm m105, did you . . .**

- 9a. Underline text?**
(Please type X in the appropriate box)

Never	
Sometimes	
Frequently	

9b. Make the text bold?

(Please type X in the appropriate box)

Never	
Sometimes	
Frequently	

9c. Write notes on paper?

(Please type X in the appropriate box)

Never	
Sometimes	
Frequently	

9d. Make notes in your Palm m105?

(Please type X in the appropriate box)

Never	
Sometimes	
Frequently	

9e. Type notes into your desktop or laptop computer?

(Please type X in the appropriate box)

Never	
Sometimes	
Frequently	

9f. Other? (Please specify)

10. When using WordSmith to read course materials on the Palm m105, did you use the "find" feature? (yes/no)

10a. How easy/difficult was it to use "Find"?

(Please type X in the appropriate box)

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

10b. How useful was the "Find" feature?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

11. When using WordSmith to read course materials on the Palm m105, did you use the "Go to paragraph" feature? (yes/no)

11a. How easy/difficult was it to use "Go to paragraph"?

(Please type X in the appropriate box)

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

11b. How useful was the "Go to paragraph" feature?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

12. How useful was the Palm m105 for reading course materials?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

13. What was the main benefit of using the Palm m105 to read course materials?

14. What was the main limitation of using the Palm m105 to read course materials?

Taking notes on the Palm m105 PDA

15. Did you use the Memo pad to record notes? (yes/no)

15a. How easy/difficult was it to use the memo pad?

(Please type X in the appropriate box)

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

15b. How useful was the memo pad?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

16. Did you use WordSmith to record notes? (Yes/No)

16a. How easy/difficult was it to use WordSmith to record notes?

(Please type X in the appropriate box)

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

16b. How useful was WordSmith for recording notes?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

17. Did you use the Notes application on your Palm m105 to record notes?

17a. How easy/difficult was it to use the Notes application?

(Please type X in the appropriate box)

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

17b. How useful was the Notes application?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

18. Did you use the onscreen keyboard to write on the Palm m105? (yes/no)

18a. How easy/difficult was it to use the onscreen keyboard?

(Please type X in the appropriate box)

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

18b. How useful was the onscreen keyboard?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

19. Did you use the "Graffiti" handwriting to write on the Palm m105?

(yes/no)

19a. How easy/difficult was it to use the Graffiti handwriting?

(Please type X in the appropriate box)

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

19b. How useful was Graffiti handwriting?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

20. Did you use any other methods to write on the Palm m105? (please specify)

Using printed materials

21. When reading printed text in the Block 4 Study Guide, did you . . .

21a. Highlight text?

(Please type X in the appropriate box)

Never	
Sometimes	
Frequently	

21b. Underline text?*(Please type X in the appropriate box)*

Never	
Sometimes	
Frequently	

21c. Write notes in the Study Guide?*(Please type X in the appropriate box)*

Never	
Sometimes	
Frequently	

21d. Write notes on a separate piece of paper?*(Please type X in the appropriate box)*

Never	
Sometimes	
Frequently	

21e. Type notes on a computer?*(Please type X in the appropriate box)*

Never	
Sometimes	
Frequently	

21f. Make notes in your Palm m105?*(Please type X in the appropriate box)*

Never	
Sometimes	
Frequently	

21g. Other? Please specify**22. Do you prefer to read course materials . . .***(Please type X in the appropriate box)*

On the Palm m105?	
On paper?	

General perceptions of the PDA

23. Overall, how useful was the Palm m105?

(Please type X in the appropriate box)

Not useful	
Somewhat useful	
Very useful	

24. What were the general benefits of using the Palm m105?

25. What were the general limitations of using the Palm m105?

26. Did you feel that you needed more technical support than you received?

(yes/no)

27. If so, what support did you need?

28. What other comments do you have about your experience of using the Palm m105?

29. What is your OU computer username?

(Please note this information is required to match pre- and post-questionnaire responses. New ID codes will be generated to ensure your responses remain anonymous)

Thank you very much for taking the time to complete this questionnaire

Your participation is very much appreciated!

Appendix C

Case Study A – Interview Questions (First Interviews)

Did you use the Palm m105 PDA to read course materials?

If not, why not?

If yes, how did the use of the PDA change the way you read the course materials?

What was different about reading from the PDA, compared to reading course materials on paper?

Were there differences in your reading strategies (e.g., reading the text in detail and/or skim-reading to pick up key points)?

Were there differences in your reading speed when using the Palm m105 compared to reading from paper?

Were you able to take notes easily on the Palm m105?

Did you find it easy or difficult to scroll through the text (as opposed to turning a page when reading a paper document)?

Did you use any other features or functions of the Palm m105 PDA?

If not, why not?

If yes, what other features or functions of the Palm m105 did you use? Did these support other study-related activities?

Overall, did you find the PDA to be a useful tool for supporting your studies?

Why/why not?

Did you experience any technical difficulties with the PDA?

If so, what difficulties did you experience?

Did you use any other tools in conjunction with the Palm m105 PDA (e.g., a mobile phone)?

How did you use them?

How would you improve the PDA so that it could be more useful for supporting your studies?

What features and functions would you like to have on an 'ideal' PDA?

Have you used any other handheld computers in the past?

If so, how do they compare with the Palm m105 PDA?

How did using the Palm m105 PDA differ from using your desktop or laptop computer?

Will you continue to use the PDA now that the study has finished?

If not, why not?

If so, what will you use the PDA for?

Do you have any other comments about your experience of using the PDA?

Appendix D

Case Study A – Follow-Up Interview Questions

Interview 07¹⁵

Interviewee: AC

29th July 02

AC is still using her Palm and "very much enjoying it". She is not studying an OU course this year, but uses the Palm as an agenda and address book (presumably for work?) and as a memo pad and place to store membership numbers etc.

Introduction: Why I am doing a follow up interview

Thank you very much for agreeing to take part in this interview. I really appreciate you giving up your time to help out. Before we begin, can I confirm that you are happy for me to record this telephone call for research purposes? I may quote from this conversation in research reports, but I will ensure that you will remain anonymous in any reference to this interview.

The H802 PDA project last year was a pilot study for my PhD research. The project involved a general evaluation of the use of PDAs as tools for reading course materials on an OU course. One of the findings that came out from the H802 study is that students varied greatly in their enthusiasm for the new technology. As a follow-up I want to find out some of the reasons for this variation. I'm interested in the use of palmtop computers in general - not just the Palm m105. I'm looking at how these new tools fit in with existing technologies and whether they complement or conflict with existing work and study practices.

You mentioned in your email that you are using the Palm primarily to support your work activities. In this interview I want to find out more about how you use your PDA and how it fits into your work and study activities.

General info

Firstly, can I confirm that you are still using your PDA?

What do you use it for?

Lifestyle

Tell me a bit about your lifestyle. How does the PDA fit into this?

¹⁵ This is an example set of interview questions. The questions were tailored to each interviewee, based on what was known about them from previous interviews, FirstClass discussion contributions, or email contact. However, many of the questions were generic and used with each interviewee.

Work activities

Do you use your PDA to support your work?

What work do you do?

What is your workplace culture like?

Do your colleagues tend to also use new technologies?

Are new technologies supplied by your work?

Is there IT support for using PDAs in the workplace?

How does the PDA fit into your work practices?

What work activities do you use the PDA to support? (e.g., time management, contacts database, note-taking, emails, etc.)

Can you describe what those activities were like before you had the PDA? How have they changed since you've been using the PDA?

Did you have to change your work practices in order to make use of the PDA?

Study activities

(not continuing with OU studies this year)

Personal preferences

What is your general attitude towards new technology?

Would you describe yourself as a typical early adopter? Why/why not?

What interface features do you like to have on a PDA? (e.g., colour screen, keyboard, handwriting, etc.)

What features or functions would you like to have on an ideal PDA?

Tools

How has the PDA fitted in with existing tools (e.g., computers, pen and paper, mobile phones, etc.)?

Has it complemented or conflicted with those tools?

Does the PDA replace other tools (such as pen and paper or the desktop computer) or is it used in conjunction with those tools? How?

Any other comments?

Appendix E

Case Study B – Extract of Observation Log

B01

Handspring Visor Deluxe + keyboard

21/06/01 - Set up procedure

All went smoothly.

Query about synchronisation with home computer - possibly need to order more cables.

Navigation difficulties: wanted to know how to 'go back' when in particular applications, e.g., when reading an email, how do you go back? (solution is to press 'done' but participant was looking for a back button or something similar).

13/07/01 - says is not using the device much. Would like more training on how to use it.

24/07/01 - conducted short training session to show B01 how to use the device. Answered specific queries about sending emails, beaming memos, and using the attachable keyboard. There was an issue about navigating between applications: "Is there a back button? How do I go back to the previous screen?" (It does not appear to be intuitive that the user has to tap on 'done' or 'ok' to close down a current screen). B01 had also not learnt how to use Graffiti handwriting. Attempted to do this without finding out how to write in Graffiti characters, which proved difficult and mostly unsuccessful. Some errors included drawing a lower-case 'a' and a lower case 't' (taking the stylus off the screen to cross the t). Another question was 'What are these arrows for?' - referring to the arrows that separate the alphabet section from the numerical section of the graffiti handwriting area. B01 believed that tapping the arrows created a dot or full-stop on the screen - however, this was only happening because he tapped the handwriting area twice - the first time put Graffiti in 'punctuation mode' and the second time created a dot or full stop (this was NOT because he was tapping on the arrows in the Graffiti handwriting area).

Also wanted to know how to turn off the system sound.

26/07/01 - Concerns about security: 'If my PDA gets stolen, can people read my emails?' - I showed him how to set up a password.

04/01/02 - Interview comments show that B01 did not use PDA much - a non-user.

B02

Handspring Visor Deluxe + keyboard

11/06/01 – Set up procedure

All went smoothly

B02 reinstalled software to enable synchronisation with Outlook diary, address book, etc.

04/01/02 - B02 has decided to discontinue use of the PDA due to frustration at having to change batteries. The Handspring operates on alkaline batteries which should last for a month or two but since B02 uses the device frequently he has to change the batteries fortnightly. Therefore, despite extensive use of the device and increasing reliance upon it, he has decided to stop using it, as described in an email.

07/11/03 - Final interview (informal conversation): B02 is an interesting case because he has left the OU and therefore had to return his PDA. After a few months in the new job, however, he decided to buy his own PDA. This is mainly because of the diary function. He toyed with the idea of getting a mobile phone with the diary capability but in the end got a fairly inexpensive PDA that served the purpose he wanted. He kept saying that he only used the PDA as a diary as if this was not how it should be used. He said he would be interested to learn of any decent learning applications for mobile devices that might be highlighted by my research.

B03

Palm m105 + keyboard

08/06/01 – Set up procedure

Synchronisation with desktop did not work. Not sure why. Needed to reinstall software to enable synchronisation with Outlook diary, address book, etc.

13/06/01 - device not calibrating properly. Pen-based input misinterpreted by PDA. Extremely difficult to use on-screen keyboard. PDA has been returned to manufacturer

13/07/01 - PDA has now been replaced

Found the set up procedure frustrating.

Instructions for installing AvantGo difficult to follow

Tried to use to record notes during conference presentations - but problem with screen calibration and loud sound (B03 not aware this could be turned off) meant that this was too frustrating and so reverted to pen-and-paper methods.

25/07/01 - Finds putting appointments straight into the PDA diary difficult - would prefer to put appointments into desktop computer, then download onto PDA.

07/12/01 - Dog ate PDA! B03's PDA is no longer functioning. Decision made to replace it with a HP Jornada which will involve another learning curve.

04/01/02 - Set up of HP Jornada did not work. The box containing the device and the manual etc was missing the CD which contained the synchronisation software. So far we have conducted a fruitless search for the correct CD. The device was previously being used by somebody else and the CD has apparently gone missing in the process of being installed.

Appendix F

Case Study B – Interview Questions (Initial Interviews)

1. What type of PDA did you use?

2. How often did you use the PDA?

less than once a week	1-3 days a week	4-6 days a week	every day
-----------------------	-----------------	-----------------	-----------

3. Did you use the PDA for the following activities?

Managing your diary	
Storing phone numbers	
Keeping to-do lists	
Taking notes	
Reading email	
Writing email	
Accessing Internet sites	
Reading e-books	
Editing word documents	
Using spreadsheets	
Calculator	
Games	
Beaming information to other PDAs	
Other (please specify)	

4. For which task(s) was the PDA most useful?

5. Overall how useful was the PDA?

1	2	3
Not useful	Somewhat useful	Very useful

6. Why / why not?

7. How easy or difficult was it to use the PDA?

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

8. Why was it easy / difficult?

9. What data input methods did you use to enter text into the PDA?
(e.g., handwriting with stylus, onscreen keyboard, foldout keyboard)

10. Which data input method did you prefer?

11. Why?

12. How easy or difficult was it to enter text in the PDA?

Very difficult	
Somewhat difficult	
Neither easy nor difficult	
Rather easy	
Very easy	

13. Why was it easy/difficult to enter text?

14. Were there any critical incidents that occurred when you were using the PDA?
(e.g., technical difficulties, lost data).

15. Did you worry about losing data? If so, what did you do about it?

16. Did you use the PDA in collaboration with other people?

17. How did you use the PDA in conjunction with other tools? (e.g., desktop computer)

18. What would you advise other people about using a PDA to support work activities?

19. How did the PDA change the way you used information resources to support your work activities?

20. What was the main benefit of using the PDA?

21. What was the main limitation of using the PDA?

22. Will you continue to use the PDA to support your work activities?

23. Do you have any other comments?

Appendix G

Case Study B – Interview Questions (Follow-up Interviews)

Interview 01¹⁶
Wed 24th April, 10.30am
Interviewee: B10

About the interview: I am doing a set of follow-up interviews with a few of the participants from the PDA evaluation. The purpose of this is to explore some of the reasons behind the variation in the success participants had in using the PDA. You were one of the more successful participants, so I wanted to find out what factors influenced this success.

In the last interview we did, you said that the PDA was really invaluable. Is that still the case?

Activities

What work activities do you use the PDA to support?
(In the last interview, you said the PDA was most useful for the diary. Is that still the case? Do you use the PDA for other work activities?)

What are the possibilities and constraints introduced by the PDA?
(e.g., what does it allow you to do that you couldn't do before? What does it stop you from doing that you were able to do before?)

Has the PDA fit in with your existing work tools - such as your computer? Does it complement or conflict with other tools?
(In the last interview, you said you used the PDA "like a little notebook all the time". Does this mean that the PDA replaces paper notebooks? Does it overcome shortcomings of paper or does the PDA create new shortcomings?)

Subject factors

How has your past experience with using other tools (e.g., computer, pen and paper, mobile phones, etc.) impacted upon the way you used the PDA?

Were you able to prioritise time to learn to use the PDA and fit it into your work activities? Why/why not?

What preferences did you have for features of the device? Were these met?

¹⁶ This is an example set of interview questions. Some of the questions were tailored to each interviewee, based on what was already known about that person's use of the PDA.

Community

What are the work groups that you belong to?

How is your work within these groups affected by the use of the PDA?

Do these groups impact upon the way you use the PDA?

Are there certain rules within the community that you work that affect the way you that use the PDA?

Do you share your workload with other people? How does this affect the way you use the PDA?

Have colleagues or friends helped you to learn to use the PDA or to overcome technical difficulties? How?

(In the last interview, you said that a friend had told you about the screen contrast button, and another friend had advised you to teach yourself Graffiti while on the train. Are there any other examples like this?)

Do you have any other comments?

Appendix H

Case Study B – Interview Questions (Final Interviews)

1. Do you still use your PDA? If so, how?
2. You mentioned that you bought a mobile phone that has PDA functionality. Has this replaced some aspects of the PDA?¹⁷
3. Why do you think the PDA (or mobile phone) has become so useful to you?
4. Has your use of the PDA changed over time? How does it fit in with the other tools that you use?

¹⁷ Questions such as these were tailored to match the circumstances of each interviewee.

Appendix I

Case Study C - Observations of Staff Seminars

Mobile Working Seminar¹⁸ Monday 15th July 2002

I attended a mobile working seminar, organised by the Information Technology (IT) team at NGC. Selected NGC employees were invited to attend the seminar, based on their responses to a mobile working questionnaire that IT had carried out. Those who had shown particular interest in issues relevant to mobile working and mobile technologies were invited to the seminar to see a demonstration of various handheld technologies and to have the opportunity to comment on their particular needs for mobile technologies in their work.

The two-hour seminar involved presentations from members of the IT team, who gave a synopsis of the mobile working questionnaire findings, and a representative from AvantGo, a company that worked with NGC to make the NGC Intranet accessible on Palm PDAs three years ago. The purpose of AvantGo's involvement in this seminar was to provide an overview and demonstration of the different handheld technologies currently available on the market. Although AvantGo is not a hardware distributor itself (it provides web content for handheld computers and mobile information management solutions for organisations), their representative at the seminar claimed they had a good understanding of the relative success of different devices and the uses people make of them in business contexts. The devices demonstrated at the seminar included the Trium smartphone – a combined mobile phone and Handspring PDA – an iPAQ palmtop computer, a Blackberry RIM, and a Hewlett Packard handheld computer. The AvantGo representative said he did not want to advocate using technology for technology's sake and highlighted some of the potential benefits and limitations of the different devices - for example the limited battery life on Pocket PC palmtop computers.

The IT team provided an overview of their strategy for technology provision in NGC Group. They are operating a three-year hardware replacement program – all computers will be replaced every three years. IT would like to reduce the cost of providing technologies and support, which is currently estimated at £25,000 per user. Ideally they would like to be consistent in the provision of technologies across the organisation. Currently, the IT service desk needs to provide technical support for a great variety of devices and applications. IT hope to reduce this by providing fewer different technologies. They also intend to only provide technologies where there is a rationalised need for those tools in the job. For example, they intend to carry out

¹⁸ Only the observation notes from the Mobile Working Seminar are reproduced here. The notes from the second seminar I attended – a demonstration for staff of the new Intranet portal – have not been included here as they do not relate explicitly to the central concerns of the thesis.

user profiling and, therefore, be able to specify the technologies needed to support each job in NGC. With regard to mobile technologies, there are currently 500 Palm computers in use in NGC. The IT team claim that Palm is “not the best device” and that NGC is “not getting the value it should” from the Palm PDAs because most people only use them for the diary and address book functions. The intention is now to discontinue the use of the current Palm PDAs and replace them with a new range of devices. It is hoped that the new devices will be used more extensively than the current Palms.

Some reflections:

- The existence of the seminar suggested that the IT team invite feedback from employees about the technologies/tools they want.
- However, there was also evidence of an attitude of using technology for technology's sake. It was implied that NGC is not getting “best value” out of Palms because people are not making use of all the available functions - often they are “only” using them as a diary. Do people have to make use of all the functions of a device in order for it to be considered valuable? Is the value of Palms as time management tools being overlooked?
- There seemed to be assumptions held by IT about mobile working practices that didn't match with what people have told me about their mobile work - i.e., IT want to provide information access for employees on the move, but the people I've spoken to about mobile working talk about producing documents, reports, preparing PowerPoint presentations, working with Excel spreadsheets and sending and receiving email. These people seem to require the full functionality of a laptop computer when working on the move.

Appendix J

Case Study C – Interview Questions

Purpose of interview:

To find out:

- The nature of mobile work at NGC
- The use of information technologies at NGC
- The use of mobile technologies (particularly PDAs) at NGC: how have they successfully and unsuccessfully supported NGC's mobile working practices?

1. Job title
2. Tell me a bit about your work.
3. What are the objectives of your work? (*i.e.*, goals, purpose)
4. How is your work shared with other people? Do you share your work with other members of the team/department, or with colleagues outside of NGC?
5. What information resources do you use in your job? (e.g., documents, web sites, information provided by colleagues, etc.)
6. What technologies do you use in your work? How are they used?
7. How mobile is your work?
For example, do you travel often within the UK or overseas? Do you work while commuting? Do you work from home? What sort of work do you do when away from the office (e.g., do you travel to attend business meetings, to carry out investigations, to attend conferences, etc)?
8. What technical tools do you use to support the mobile aspects of your work?
9. Do you use a PDA? (e.g., Palm)
10. If not, did you previously use one? Why are you no longer using it?
11. If yes, what do you use it for?
12. How does it fit in with your working practices? Has it changed your working practices? How?
13. How does it fit in with the other tools/technologies that you use? (Does it complement or conflict with existing tools - e.g., desktop/laptop computer, mobile phone, pen and paper?)
14. How useful is the PDA?

15. Do your colleagues/friends use PDAs or similar devices?
16. Have you used similar devices in the past?
17. What tools/technologies would you prefer to have to support the mobile aspects of your work?
18. Do you have any other comments?

Appendix K

Notes from PDA tour of Tate Modern Art Gallery

Thursday 11th December 2003

I took part in the PDA tour myself, along with a volunteer (Matthew). We both looked at all the exhibits that were included in the PDA tour (19 in total) and tested the available functions, such as sending text messages, emailing information home, and so on. I took notes of my own observations and recorded Matthew's responses to the tour. We both found it to be a fun and interesting tour. I also spoke to four other people who did the tour. They were not typical users as one worked in the gallery and the other three were visitors from another gallery who were assessing the potential for implementing PDAs in their own gallery. These were not formal interviews – rather informal conversations. I just wanted to get an idea of what people who used the PDAs thought of them as a learning tool in this context.

Observation notes

Interface: It did not take long for either myself or Matthew to become familiar with the screen interface, which was fairly simple and uncluttered. A 'home' icon at the top of the screen brought you back to the main menu which consisted of five or six items such as:

- map
- select work (this brought up the information about the selected work)
- gallery information
- text message
- juke box
- other options?

Doing the tour: When you pressed 'select work', you were shown a screen of a number pad and had to select the number of the work you were currently looking at. In the gallery, the numbers were displayed next to the work with an 'M' symbol to indicate that it was part of the multimedia tour. I sometimes found it difficult to see the numbers as they were not prominent in the gallery and when particular rooms were crowded it was difficult to get close enough. When I spoke to Matthew about this, he told me that he preferred to use the map. Selecting the 'map' item from the home menu brought up a simple map of the Floor 3 layout with numbers to indicate where paintings or exhibits were included in the multimedia tour. Selecting those numbers brought up the corresponding tour item on the PDA screen.

After selecting a work to be displayed a simple menu appeared on the PDA screen. Selecting an item from that menu started the audio tour, heard through head phones attached to the PDA. The audio tours consisted of a narrator providing background information about the work, sometimes including quotes from the artist and, for

some works, accompanying music (e.g., the artist's favourite piece of music). For instance, when viewing Pollock's 'Summertime: Number 9A', there was the option to listen to Pollock's choice of music. There was also the option of viewing video footage of Pollock creating his work.

For some works there were also opinion polls. For example, when viewing the multimedia tour for item number 19, which was the Mark Rothko room, consisting of a series of paintings by Mark Rothko, an opinion poll asked 'how do you feel in this room?' There were five possible responses that could be selected by tapping the screen with the pen: happy, calm, depressed, anxious, claustrophobic. The PDA was then supposed to display a simple graph illustrating how other visitors had responded to this question. However, this did not work for this particular poll - instead, the screen froze, causing some confusion among users. I came across a group of people who were experiencing this problem when I arrived in the Mark Rothko room and it was clear that they were concerned the PDAs had broken. The solution to the problem was to press the 'home' icon to return to the main menu, and then reselect the work to go back into the audio tour; this was a frustrating process.

There were also two 'games' included in the tour, although one did not work (this was the 'surrealist' game associated with the Salvador Dali 'Lobster Phone' exhibit. When selecting this option the PDA screen froze). The other game was an option when viewing a series of works called 'Four Seasons' by Cy Twombly. The purpose of the activity was to match each of the paintings to the appropriate season, as each painting was said to represent a particular season (I was already attempting to do this in my head before realising it was an activity on the PDA). The paintings were reproduced on the PDA screen and to do the activity you had to drag the season name across to the appropriate image on the PDA, using the pen stylus. Matthew correctly matched all the paintings with the seasons. I didn't, although I realised when the audio tour continued that I had mistaken one of the images on the PDA for the wrong picture on the wall. I found the images on the PDA to be quite small and difficult to see. After completing this activity, the PDA returned to the main menu and so to continue the audio tour for that particular exhibit you had to re-select the appropriate work. It would have been preferable (for me) if the PDA had returned to the menu for that particular audio tour item.

There were also some 'touch and hear' items which showed the art work on the screen with circles around particular aspects of it. The user was required to select one of the circles which would then bring up more information about that particular aspect of the work, e.g., more detailed images and an audio description of the object. This feature was particularly useful for items where it was not clear what the objects were or items that required further explanation of particular points (e.g., the garden shed explosion).

The audio tour for item number 3 involved a curator describing the elements in the picture - a Cubist painting called 'Clarinet and Bottle of Rum on Mantelpiece' by Georges Braque. Looking at the painting, it was difficult to make out the different elements in the picture. The multimedia tour helped, with a curator discussing each aspect of the picture while it was highlighted on the PDA screen. While I found this helpful, another person doing the tour (D02) said that he felt that having elements of

the picture highlighted on the PDA screen did not add anything to his understanding of the exhibit.

Some items also included video footage. For example, the garden shed explosion had a video of the assembling of the shed. The 'how do you feel' room included video footage of other gallery visitors explaining how the room made them feel.

When the tour information for a particular work had been completed there was no 'done' option. Instead you had to go back to the home menu and choose 'select work' or the map all over again. I found this awkward and would have preferred to have a 'select work' icon available at the top of the screen at all times.

Menu selections were made with a pen supplied with the device. Although the PDA had a neck strap I found that I still needed to hold it in order to view the screen. Carrying the pen as well was awkward and it was very difficult to also carry a notebook and pen. I noticed that many of the school children visiting the gallery were carrying pen and paper, as were many other visitors. I wonder if a facility to record notes would be a valuable addition to the PDA? I also had an accident when trying to switch between PDA pen and paper and pencil - the PDA pen fell out of my lap and disappeared down a grate in the floor!

The text messaging was an interesting idea but I found it a bit limiting. Selecting the 'TATE.txt' option from the main menu brought up the text messaging facility, which allows the user to send messages to other visitors doing the PDA tour. Initially, there are two options: 'send txt messages' or 'read txt messages'. It is only possible to know whether you have received a text message by selecting the latter option (there is no 'unread messages' icon on the screen or anything like that. Therefore, you could waste a lot of time selecting 'read messages' just to check whether you had received any messages. Selecting the option 'send txt messages' brings up a list of names of the people currently doing the PDA tour. You have the choice of sending a message to 'everyone' or to one particular person on the list. When attempting to send a message to my brother I accidentally selected the wrong name. There was no option to cancel or select 'undo' or any other action to correct my mistake. Instead, I had to go back to the 'home' menu and select 'TATE.txt' all over again. I also experienced difficulty when I tried to scroll through the list of names that appeared as possible recipients of the message. There did not appear to be any way of scrolling down the list and when I tried to do this - by placing the pen at the bottom of the list - the PDA froze. Again, the solution to this problem was to select the 'home' menu. I came across somebody else doing the tour who had also just tried to scroll through the list of names and found her PDA had frozen. A technical glitch had clearly occurred here, causing a breakdown in our attention focus - from the exhibition to the device.

When creating a text message, you could only choose from specific messages (e.g., 'I am ... tired/cold/hungry/bored/etc'). There was no option to say 'where are you?' which was the one message I wanted to send when I lost Matthew for a while. The option to choose a 'where are you' message with the ability to respond using the map would have been good. Also, I noticed that the other visitors to the gallery who were not using the PDAs and who were in groups or pairs often talked to each other when they were looking at exhibits. For instance, two school aged girls made loud

exclamations when they saw Salvador Dali's lobster phone. I also spoke to my companion on numerous occasions about particular exhibits. I wonder if the text messaging option is supposed to emulate this interaction, and if so, how it could compare with physically seeing another person and speaking to them about the work?

It would also have been good to have been able to send a text message while also listening to the audio tour, rather than having to stop the tour and go back to the main menu in order to create and send a message.

At the end of each tour item there was also the option to 'send an email home'. Selecting this meant that that particular tour item would be added to your 'bookmarks' and the information sent to your email address at the end of the tour. This is a great idea but you have no idea what you are going to receive (e.g., a text version of the audio tour?)

[Additional note: upon returning to my office and checking my email, it appears that there may be problems with this system. The email I received said the information I requested was 'below' but no information appeared, other than general gallery info.]