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Part 1 – Background

Chapter 1 – Introduction

Customisation is considered to be a standard means by which users are able to appropriate the technologies that they use (Mackay, 1990; Clement, 1993). For now, it is sufficient to understand the term appropriation as the process by which people fit technologies into their daily lives and their working practices. Thus, it concerns the adoption patterns of technology, the transformation of practice in response to the introduction of the technology, and the customisation of technology necessary to make the technology usable and useful within the setting (Orlikowski, 1996; Dourish, 2003; Törpel et al., 2003). By customisation, we mean those changes made by users themselves to the technology and its associated documentation and procedures (Trigg and Bødker, 1994).

This thesis hopes to extend the research on appropriation and customisation of technologies. What largely distinguishes this thesis from previous studies of appropriation and customisation is its focus on the setting of intensive care and its concern with medical devices. Much research has been carried out within the fields of Human-Computer Interaction (HCI) and Computer Supported Cooperative Work (CSCW) on the topics of appropriation and customisation (e.g. Grudin, 1988; Mackay, 1990; Gantt and Nardi, 1992; Orlikowski, 1992; Clement, 1993; Bowers, 1994; Rogers, 1994; Trigg and Bødker, 1994; Bikson and Eveland, 1996; Dourish, 2003). However, little attention has been paid to these topics within medical settings. The research that has been carried out in medical settings has largely focused on information technologies, as opposed to medical devices. By looking at the setting of intensive care and the use of medical devices, a whole range of new and interesting issues are raised, including how concern for patient care affects the response to a new device and how safety concerns are dealt with when making customisations to devices.

This chapter describes the objectives of the thesis and the motivation behind those objectives, and the main research questions that this research addresses. The chapter concludes with an outline of the remainder of the thesis.

1.1 Objectives and research questions

It is intended that this thesis will shed light on the ‘missing detail’ of one aspect of technology use in the intensive care unit (ICU), by considering the process of appropriation

of medical devices within that setting. The thesis aims to describe the tacit work practices and procedures that intensive care nurses use in responding to problems with, and the limitations of, equipment. The focus is on customisation as a means for overcoming the problems and limitations of technology. Hence, the main objective of this research is:

- To gain a detailed understanding of how nurses appropriate equipment through the practice of customisation, including an understanding of the work practices that surround and support such customisation.

This objective is motivated by the potential significance that customisations to medical devices can have, in terms of patient safety and staff accountability. An example of a well-known customisation within the medical domain, and one that has resulted in serious injuries, is the ‘broken needle technique’ used to obtain blood from small infants (MDA, 2001b). As a result of the potential consequences for patient safety, within the medical domain both researchers and regulators have understandably focused on the potential threat to safety created by such changes (e.g. Cook and Woods 1996; Obradovich and Woods, 1996; MDA, 2001a). Such customisations are often put into the categories of ‘user error’ and ‘poor practices’ by regulators (e.g. MDA, 2001a; MDA, 2001b). When such ‘poor practices’ are identified, the Medicines and Healthcare products Regulatory Agency publish and circulate a document to hospitals to warn of the dangers of such practices and detailing what is considered by them to be the appropriate practice (for an example of this, see (MDA, 2001a)). For example, in response to the ‘broken needle technique’, the Medical Devices Agency (what is now the Medicines and Healthcare products Regulatory Agency) issued a safety notice (MDA, 2001b). However, the work practices surrounding such customisations are not explored. This thesis works on the premise that, if such customisation is happening, it is important to have a better understanding of the types of customisations that are occurring and the motivation behind the customisations.

Although the main objective of this thesis is to focus on providing a detailed description of the process of appropriation and the role of customisation within that, it is also important to consider the significance of such practices for design. Therefore, an additional objective of this thesis is:

- To consider what the significance of such customisation is for design, in terms of the extent to which customisation should be supported and how this can be achieved.

This second objective is motivated by the fact that there has been much research within the fields of HCI and CSCW into customisable systems (e.g. Greenberg, 1991; Bentley et al., 1992a; Neuwirth et al., 1994; Bentley and Dourish, 1995; Dourish, 2003) but little, if any, of this has been transferred to the medical setting. This thesis hopes to consider the reasons for this absence, and to see if there are possibilities for customisable technologies in medicine.

Following on from these objectives, two main research questions emerge:

- What work practices surround and support the appropriation and customisation of medical devices by nursing staff?
- To what extent should we be supporting the customisation of medical devices by nursing staff and how can we support it?

The central chapters of this thesis focus on answering the first of these two questions. The second research question is addressed following on from this.

1.2 Approach and results

This research used ethnographic methods to answer the research questions, as this provided the opportunity to study the appropriation and customisation of technologies as it is carried out by those in the setting, and to gain an in depth understanding of the practices surrounding such appropriation and customisation (Heath and Luff, 2000; Crabtree, 2003). The study can be considered as an ethnomethodologically-informed ethnography. By this, we mean a study where the data is collected through the use of observational methods and where emphasis is placed on being able to provide detailed descriptions of the setting and its activities, using the terms of those in the setting, rather than restricting our descriptions by relying on the language of a particular theory (Crabtree, 2003). Rather than taking a moral stance on the activities observed, the concern is to describe the perspective of those in the setting on the activities. This study thus follows in the tradition of variety of researchers working in the fields of HCI and CSCW who are using such methods (e.g.

Bentley et al., 1992b; Button and Harper, 1993; Harper and Hughes, 1993; Suchman, 1993; Heath et al., 1999; Hartswood et al., 2003a).

In understanding the collected data, there were two main concepts relating to the nature of human action and interaction that were drawn upon. The first concept is the ethnomethodological conception of accountability (Garfinkel, 1967). Ethnomethodologists are concerned with the accountability that we feel to colleagues, friends, and family. We can refer to such accountabilities as local accountabilities, in contrast to the more formal accountabilities that we have in relation to employers and the like. Wenger (1998) uses the term ‘mutual accountability’. It is ethnomethodology’s contention that what it means to be a member of a community is to share a set of local, contextual understandings of how to act, and how to understand action, within that community. This conception of accountability is important in considering the appropriation and customisation of medical devices within the ICU, because it encourages us to consider not only the nurses’ formal accountabilities but also the local accountabilities that encourage them to customise and persist with the technology.

The second concept is the notion of situated action, which considers that every course of action depends in essential ways upon its material and social circumstances (Suchman, 1987). This is an idea that has received much attention within the fields of HCI and CSCW. It is important in considering the appropriation and customisation of medical devices within the ICU, because it provides a means to understand users’ attempts to customise the procedures that surround various technologies and to overcome the procedures that are inscribed within them, as well as emphasising the importance of local needs and local practice.

In the analysis of the ethnographic data, it was found that, in appropriating the technology, customisation was a standard procedure that nursing staff used to overcome the problems and limitations of equipment. However, these customisations were not the *ad hoc* changes of individuals. Rather, they were discussed amongst colleagues and those customisations that started as the customisations of particular individuals soon became part of local practice. Many of the customisations were made necessary due to the situated nature of work within the ICU. It is also argued that the customisations arose out of local accountabilities and, as a result, customisations were carried out with respect for local

understandings of accountability. As well as enabling the nurses to overcome the problems and limitations of equipment, certain customisations could also be seen as allowing the nurses to use the equipment in ways that were more fitting with their local practice. Therefore, this thesis argues that greater support for the customisation of devices by nurses should be provided in the design of such devices.

1.3 Outline

A short sketch of the chapters which follow provides an outline of the investigation presented in this thesis:

The thesis is divided into three parts. The rest of **Part 1** provides further background to the thesis. **Chapter 2** identifies the fields of research that are relevant to this thesis: studies of appropriation, studies of customisation, and workplace studies generally. The intensive care setting is described, and the research questions of the thesis are further defined. The intention of **Chapter 3** is to provide the theoretical background to this investigation. It describes the assumptions about human action and interaction on which this thesis relies, describing the ethnomethodological conception of local accountability and the notion of situated action. **Chapter 4** discusses several methods that could be used for learning about the use of intensive care equipment. It describes the ethnographic approach that this thesis uses, along with the ethnomethodological approach used to analyse the data. The limitations of ethnography and ethnomethodology are discussed. Finally, the issue of how to validate the analysis is examined.

Part 2 consists of three chapters that present the analysis of the collected ethnographic data. **Chapter 5** recounts the introduction of a new device into an ICU, in order to explore how nurses appropriate a new device and how they attempt to overcome problems with the device, both in terms of malfunctions and more general limitations of the device. This also allows for discussion of some typical problems that nurses experience in their interaction with medical devices. Aspects of their relationship with the devices' manufacturers and distributors are described. The chapter highlights how the response to problems is a situated activity that draws on local understandings of accountability. **Chapter 6** then shows how customisation is a practice used within the process of appropriation. The chapter investigates how nurses customise equipment as a way of responding to the limitations of devices. It identifies not only the kinds of customisations that are carried out

and who they are carried out by, but also delves into what is treated as an adequate reason for customisation and how safety concerns are dealt with. **Chapter 7** analyses the use of adjustable alarms in intensive care as an example of a customisable technology. It looks at the factors that nurses consider in the setting of alarm limits, how understandings of accountability are displayed in the setting of alarm limits, and how the setting of alarms is a way in which nurses demonstrate themselves as competent members.

Part 3 concludes the thesis by summarising the findings of the research presented in Part 2 and by considering the implications of that research for the design of medical devices. **Chapter 8** draws together the findings to answer the question, ‘What work practices surround and support the appropriation and customisation of medical devices by nursing staff?’ **Chapter 9** uses these findings to answer the second research question, ‘Should we be supporting the customisation of medical devices by nursing staff and, if so, how?’ The chapter considers the extent to which technologies currently available within the ICU support customisation and how they do this. It then considers two approaches from the field of HCI and CSCW that developed in response to the phenomenon of user customisation. The first involves the development of easily customisable technologies. The second involves a reallocation of resources in the systems lifecycle, so that the later stages of design are carried out within the work setting once the technology is in use. How such approaches can be adapted for the medical domain is considered. **Chapter 10** summarises the findings and conclusions of the thesis. The theory and methodology used within the research are reflected on. The chapter discusses the limitations of the thesis and unearths some future directions for research.

Chapter 2 – Field and focus

The previous chapter introduced the objectives and research questions of this thesis. In this second chapter, the research is specified further through the description of relevant research fields and the focus of this research within those fields. The intention is to identify how the research presented here relates to research previously carried out within those fields, and to use this to further breakdown the defined research questions.

There are three main areas of research to which this research may contribute. This research is concerned with how nurses customise medical devices. This can be seen as part of the process of technology appropriation. Therefore, two main areas of research can be identified to which this thesis contributes: those studies that consider the appropriation of technologies by users (Section 2.1) and that consider the customisation of technologies by users (Section 2.2). Due to the nature of the study, this research can also be seen as part of the growing collection of ‘workplace studies’ that consider how technologies are *made* to work within particular work settings (Section 2.3). Below, a brief summary of each field is provided, highlighting the aspects that are relevant to this thesis. This is in order to position the research presented here within those fields, thus identifying what this thesis can potentially contribute.

Because this thesis focuses on the setting of intensive care and the devices used within that setting, the chapter concludes by giving some background to the setting and the associated technologies.

2.1 Appropriation of technology by users

This section presents an overview of research into appropriation of technology by users.

This is organised around three basic questions:

- What are the main characteristics of appropriation?
- What are the main areas of change in the process of appropriation?
- How can appropriation be supported?

Research looking at appropriation in the medical domain is discussed, and the section concludes by considering how the research presented in this thesis relates to previous research.

2.1.1 What are the main characteristics of appropriation?

The Oxford Dictionary of English (2003) provides the following definition of the term appropriation:

Appropriation 1. The making of a thing private property, whether another's or (as now commonly) one's own; taking as one's own or to one's own use.

In relation to technology use, definitions of the term tend to be vague and, accordingly, the term is used in a variety of ways. For the purpose of this thesis, we will define the appropriation of technology as the process by which people fit technologies into their daily lives and their working practices. It concerns the adoption patterns of technology, the transformation of practice in response to the introduction of the technology, and the customisation of technology necessary to make the technology usable and useful within the setting (Orlikowski, 1996; Dourish, 2003; Törpel et al., 2003). Thus, a technology can be said to have been appropriated by its users if it has been harnessed to support the requirements of those users and if those users have been able to ‘take ownership of the technology’ (Ciborra, 1996, p.11).

A concern for appropriation as a research topic initially arose in response to stories of systems that had been rejected by their intended users, particularly within the field of CSCW (e.g. Grudin, 1988; Markus and Connolly, 1990; Orlikowski, 1992; Bowers, 1994). Naturally, such stories resulted in an increased desire to understand how to support appropriation and what to avoid. CSCW now has a plentiful supply of accounts of implementation experiences, including positive implementation experiences (e.g. Bikson and Eveland, 1996). After the initial surge in interest in this particular topic, attention seemed to die down. However, interest in the topic appears to be renewed, with a recent issue of *Computer Supported Cooperative Work* on ‘the evolving use of groupware’, which presented a series of longitudinal studies looking at appropriation of new technologies (Andriessen et al., 2003).

The process of appropriation is considered to consist of the mutual adjustment of both organisational and technological elements (Mackay, 1990; Rogers, 1994; Trigg and

Bødker, 1994; Bikson and Eveland, 1996; Orlikowski, 1996; Dourish, 2003; Törpel et al., 2003). Rogers (1994) emphasises this in her term ‘co-evolution’. This distinguishes the concept of appropriation from other concepts that deal with only one side of the relationship, such as the concept of customisation discussed below.

Appropriation is seen as part of an ongoing and natural process that cannot be completely anticipated. The same technology can be appropriated in very different ways by different user groups. For example, Orlikowski (1992) argues that organisational elements are significant in the appropriation of technology, in terms of the users’ perceptions of the technology and the organisation’s policies and norms.

Not only will a technology be appropriated differently within different organisations, but within those organisations there may be a multiplicity of approaches on the individual or subgroup level (Huysman et al., 2003;). Törpel et al. (2003) describe the appropriation of a groupware system by a network of freelance workers. There are two hundred freelancers in the network, as well as around another three hundred people who occasionally work as part of the organisation. This network could be considered as being made up of various smaller groups and the appropriation of the groupware varied amongst these groups. For example, when inexpensive groupware applications became available in addition to the main groupware system used by the network, individuals and groups introduced a whole range of them and formed their own practices surrounding these technologies. By using a variety of technologies in this way, the main groupware system was no longer expected to meet differentiated requirements. One regional group went as far as to develop its own groupware product. Another regional group went on to experiment with mobile devices such as smartphones and personal digital assistants (PDAs). Huysman et al. (2003) report on an exploratory study of the appropriation of communication tools by six globally distributed teams. All teams were assigned a comparable engineering design task. Because each team took a distinctive approach to the task, team-specific routines developed around the communication tools. Huysman et al. use the notion of ‘media stickiness’ to describe the way in which early decisions taken by the different teams seemed to restrict their later use of the communication tools.

As well as being a natural and unpredictable process, appropriation is typically a gradual process (Bikson and Eveland, 1996). For example, Orlikowski (1996) found that changes

are often realised through the ‘ongoing variations which emerge frequently, even imperceptibly, in the slippages and improvisations of everyday activity’ (p.89-90). Thus, while the organisation she studied changed significantly over a two-year period following the introduction of a new system, the transformation occurred through the ongoing, gradual adjustments and improvisations of those in the setting. (This study is discussed further in the following section). However, there are exceptions to this. Tyre and Orlikowski (1994) studied the appropriation of technology in three different organisations and found that change largely took place in a short period following the initial installation. Further changes tended only to be triggered by unusual events, such as new project requirements or a change in work procedures. This fits with the notion of ‘media stickiness’ described above (Huysman et al., 2003).

2.1.2 What are the main areas of change in the process of appropriation?

As described above, appropriation is typically considered to consist of the mutual adjustment of both organisational and technological elements. In terms of organisational elements, there can be a wide variety of forms of change.

An important aspect is task changes. These relate to changes in the distribution and organisation of work, as well as changes in the nature of the work. For example, Orlikowski (1996) studied the introduction of an Incident Tracking Support System (ITSS) at the customer support department of a software company. She found that the structure of the organisation changed considerably over the two years following the introduction of the system. These changes concerned the nature of the work, the patterns of interaction, the distribution of knowledge, and the patterns of coordination. For example, because of the increased documentation on calls required by the system, managers had much more information on workload and the temporal flow of calls, allowing them to justify an increased headcount and dynamically adjust schedules to deal with local workflow changes. Coordination with other departments was changed by the implementation of bug tracking systems that were linked to ITSS. This allowed specialists to directly transfer bugs that they had discovered to the appropriate bug tracking systems, thus easing the task of reporting bugs.

Another example of task changes comes from Rogers’ (1994) study of the introduction of a computerised multi-user booking and ticketing system in a travel centre. The introduction

of the system led to changes in the work procedures of those on the shop floor. One of the main changes was that details could no longer be easily changed on confirmed bookings, requiring the sales consultant to delete the file and create a new one. This clearly created more work for the sales consultants, but benefited the accountancy staff, who could be assured that a booking would remain fixed after they checked them against payments received.

Of course, organisations are made up of individuals and much of the adjustment occurs at an individual level. In terms of the users' attitudes towards and relationship to the technology, an important aspect of appropriation is the user finding a way to map the system's features to their own needs (Dourish, 2003). Appropriation concerns the way in which technology comes to play a role within the users' system of meaning. Therefore, an important part of appropriation is the process by which features of the system become meaningful, so that users understand how the system is consequential for their work and are able to interpret and understand the information presented and represented by the system. For example, to use an example from the medical domain, for an interpretative electrocardiograph (ECG) machine to be appropriated and used effectively, its users not only need to learn how to read the analysis that the system gives. They must also come to an understanding of the role that the system will play within their work, whether it will be relied upon to give an accurate assessment, or whether it is a tool that must always be used in conjunction with professional assessment (Hartland, 1993). (This example is discussed further in Section 2.1.4, when studies of appropriation in the medical domain are considered). Although occurring at an individual level, such change is also inherently social and thus members of particular groups in an organisation are often found to have similar systems of meaning.

Technological changes concern changes to the system itself and artefacts surrounding the system, such as user manuals. These changes may be made by the developer, at the users' request, or may be made by the users themselves. Such user customisation will be discussed in Section 2.2.

2.1.3 How can appropriation be supported?

Section 2.1.1 described how initial interest in the topic of appropriation arose in response to stories of systems that had been rejected by their intended users. Because of this initial

motivation, many of the earlier CSCW studies of appropriation focus on practical measures for supporting appropriation.

One focus is on how to involve users in the change process. For example, Bikson et al. (1996) suggest organising a selection of users into an ‘implementation team’. Rogers (1994) suggests employing a third party to act as mediators, feeding back the experience of users to the managers and designers and highlighting areas for further change. Clement (1993) argues for the work of appropriation, the effort of getting the technology to work, to be more explicitly acknowledged and supported.

However, although previous studies have highlighted how flexibility of working practices can support appropriation, appropriation also requires flexibility in the technology, particularly with regard to the way in which the technology can be mapped to user needs. It seems that there is now also a desire to consider appropriation more fully, to move beyond the practical measures, in order to consider the technical features that support appropriation (Dourish, 2003). Developments for allowing users to have more control over the technologies they use, including through the creation of customisable systems, will be discussed in Section 2.2.4 on supporting customisation and explored more fully in Chapter 9.

2.1.4 Appropriation in the medical domain

There have been several studies of appropriation in the medical domain. For example, Berg (1997) provides an ethnographic study of the work necessary by practitioners in order to get decision-support tools to ‘work’. The need to get these tools to work does not mean that those tools were malfunctioning or were in any way technically faulty. Rather, without making changes to work practices, the tools themselves, and how the tools were used, the tools could not fit with the work of the practitioners; the tools needed to be *localised*. In the case of the decision-support tool that was created in a Leeds hospital and was being introduced into a Swedish hospital, organisational setups had to be examined and sometimes adjusted, and the Swedish physicians had to be trained to adopt the same terminology and investigation techniques as their Leeds colleagues (Berg, 1997).

Novek (2002) provides a study of the failure to appropriate an automated drug distribution system. The system was being introduced into a hospital that was known for its

commitment to using the latest technology. The hospital was also known for the influential role that the nursing department played in its administration. A key feature of the new system was its ability to achieve relatively tight control of medication administration. This was achieved through the introduction of standardised times for medication administration throughout the hospital, a time lock function, and an electronic medication count. The nurse was given a two hour time ‘window’ to withdraw the medication from the cabinet, after which time she would be ‘locked out’. However, this conflicted with the work practice of the nurses, who wished to maintain flexibility in order to be able to prioritise their daily tasks in response to changing workloads. Time in this sense was seen by the nurses as a resource to be conserved for unplanned contingencies. The system thus required quite significant changes in work practice in order for the system to be workable, or rather for it to be workable in the way that its developers had intended. What happened instead was that the nurses soon developed ways to workaround this feature of the system. These changes to procedures are described in Section 2.2.5 that considers customisation in the medical domain.

There have been few studies of appropriation concerned with medical devices. However, four notable studies of the appropriation of medical devices are those by Barley (1988), Hartland (1993), Cook and Woods (1996) and Obradovich and Woods (1996).

Barley considered the introduction of a computerised tomography (CT) scanner into two different radiology departments. Barley’s account focuses on the response of the technologists and radiologists to technical problems, in terms of how they attempted to understand and resolve the problems. He identifies a series of strategies that were developed for dealing with the problems. A first approach was often an attempt to normalise the problem. If a problem occurred during a scan, technologists would typically attempt to construct accounts for why the problem need not be taken seriously. When technologists faced problems that could not easily be normalised in such a way, they would engage in behaviour that had successfully eliminated a problem on previous occasions. For example, they would often repeat the last command or reboot the computer. Even when a ‘ritual solution’ such as this was immediately shown to be ineffective, the technologists would repeat the solution several times before concluding that it brought no progress. Some of these approaches will be returned to in Chapter 5 of this thesis, when the introduction of a device into an ICU is considered.

Hartland (1993) studied the introduction of interpretative ECG machines in two hospitals. The interpretation of ECGs is a complex activity. When carried out by a doctor or a technician, determining whether or not an ECG is normal requires the practitioner to take into account the patient's age, race, body size, and medical history. Exactly how an ECG is interpreted is also very much tacit knowledge for practitioners, as it is something that is largely learnt through experience. In contrast, the interpretative ECG machine applied criteria in a pre-specified manner and, as a result, could make drastic mistakes. The machine also had difficulty distinguishing between acceptable and unacceptable input, unable to tell if there had been a mistake in applying the electrodes to the patient.

The manner in which the interpretative ECG machines were used varied widely between the two hospitals. In the larger of the two hospitals, Hartland found that the practitioners were aware of the limitations of the machines and adapted their working practices to accommodate them. Because there was sufficient cardiological expertise available within the hospital, all the ECG traces were routinely and automatically checked. Experienced practitioners did not accept the normal/abnormal distinction made by the machine but instead relied on their own interpretations. In fact, Hartland found that most of the technicians never used the interpretation mode, because checking the interpretation and recording another trace when necessary was considered to be a waste of time. Using the interpretation facility itself was also time-consuming, because it involved asking the patient detailed questions, typing in their answers, and then waiting for the machine to produce an analysis at the end of the ECG recording. Therefore, the technicians would typically either extract the ECG from the machine before it had printed the interpretation or would request a measurement-only report, ignoring the interpretation facility. Hartland points to how 'charitable' the users were towards the machines. Rather than making a complaint to the manufacturer, the mistakes were noticed and rectified by the practitioners. However, in the smaller of the two hospitals studied, there were no resident cardiac staff and therefore the machine was often relied on to give a definitive ECG interpretation. Thus, in this case, the extent to which the machine was used and accepted was dependent very much on the local material circumstances.

Cook and Woods (1996) looked at how anaesthetists attempted to overcome problems with a new highly integrated, microprocessor-based physiological monitoring system. Both as individuals and as a group, they made changes to their behaviour, what Cook and Woods

called *task tailoring*, and changes to the system, what they call *system tailoring*. An example of task tailoring was the strategies formulated by the anaesthetists in order to overcome the difficulties they had in operating the system. A common problem was accidentally selecting the wrong option from the various menus, partly due to the target size of the menu choices. To overcome this, the anaesthetists used a variety of techniques, such as pressing the screen forcefully, so much so that they would sometimes displace the computer backwards several inches; holding their finger exactly perpendicular to the screen surface and slowly advancing their finger until the select option was activated; or using a pencil or some other ‘pointing device’, rather than their finger. Changes to the system identified in this study will be discussed in Section 2.2.

Obradovich and Woods (1996) provide a study of how nurses adapted a computer-based device for the infusion of terbutaline in the treatment of preterm labour, for use by women experiencing high-risk pregnancies. However, the study focuses on changes to the system and its associated procedures and artefacts, and therefore it will be discussed below in Section 2.2 on customisation.

2.1.5 Thesis focus: Appropriation of devices in the ICU

Medicine is an interesting area to study the appropriation of technology because it is an area where there are a variety of potential user groups. This thesis focuses on the appropriation of medical devices, as opposed to the appropriation of medical information technologies. Clearly, problems during the appropriation of either could have serious consequences. The difference between considering medical information technologies and medical devices is that the use of medical devices can have very direct implications for patient care, because the device is, in some form, treating the patient and is often actually attached to the patient. Therefore, concern for safety is typically much greater and there are a whole host of procedures surrounding the use and maintenance of medical devices to promote safe use.

Several theoretical approaches to the study of appropriation have been developed, such as Adaptive Structuration Theory (AST) (DeSanctis and Poole, 1994) and sociotechnical systems theory (Bikson and Eveland, 1996). However, as will be discussed further in Chapter 4, this thesis will not draw explicitly on such theories, as the intention is to develop a rich description of the process of appropriation, rather than to develop or expand

theory (Crabtree et al., 2000). The literature described above focused on the appropriation of information technologies, particularly in office settings, so another concern of this thesis is to consider how these notions apply to the appropriation of medical devices. The concern is to identify whether or not appropriation is supported, either through the design of the technology or through the work practices surrounding the use of the technology, and if so how.

2.2 Customisation of technology by users

Appropriation has been described as the mutual adjustment of both organisational and technological elements. When the adjustment of the technological elements occurs through changes made by the users themselves, we refer to this as customisation. Thus, the appropriation of technologies often involves their customisation. In this section, an overview is presented of research into customisation of technology by users. This is organised around four basic questions:

- What is meant by customisation?
- Why does customisation occur?
- Who are these customisations carried out by?
- How can customisation be supported?

Research looking at customisation in the medical domain is discussed, and the section concludes by considering how the research presented in this thesis relates to previous research.

2.2.1 What is meant by customisation?

Customisation has been considered in many areas of technology use, and accounts of various types of customisation can be found in the fields of HCI and CSCW (e.g. Gasser, 1986; Mackay, 1990; Gantt and Nardi, 1992; Clement, 1993; Trigg and Bødker, 1994). However, as with appropriation, definitions of the term vary, so again we will begin with a dictionary definition. The Oxford Dictionary of English (2003) provides the following definition of the term ‘customise’:

Customise *verb* **1.** To make or change something according to the buyer's or user's needs.

Within the HCI and CSCW literature, studies of customisation typically report changes made by users themselves to the technology and its associated documentation and procedures (Dourish, 2003). Customisation is seen as an important part of the process of appropriation. It is a way for users to attempt to overcome limitations of the technology. It is also a way for them to adjust the technology to fit with both their local practices, often referred to in the literature as ‘localising the technology’ (Berg, 1997), and their personal needs. Studies within the fields of HCI and CSCW have typically seen such customisation as a positive attempt by users to appropriate the technologies they use in their daily lives (e.g. Clement, 1993).

The extent of such customisations varies. The majority of customisation studies to be found in the HCI and CSCW literature focus on the office setting. These studies typically describe customisations that are supported by the technology. For example, Gantt and Nardi (1992) describe the use of computer-aided design (CAD) packages at a variety of companies, ranging from architectural firms to Fortune 100 companies. Customisations varied from changing the colour of a menu or the location of a menu item to editing parameters in a macro and writing new macros. Clement (1993), in his study of the introduction of a computer system into an administrative support office, describes customisations such as the development of spreadsheet templates, word processing macros, and document layouts. Trigg and Bødker (1994) studied the introduction of PCs into a governmental organisation. Two members of staff were given full responsibility for customising the technology, implementing changes that they felt were appropriate or that other members of staff requested. The customisations described are similar to those described by Clement (1993). The main customisations were the development of word processing macros and the building and modifying of WordPerfect buttons.

As well as customisation of technology, there have been many reports of customisation of user manuals and the procedures that surround the use of technologies. For example, Bell et al. (1997) describe a study of Xerox customer service engineers and their use of the service manual. They found a significant discrepancy between the documented processes provided in the service manuals and the actual practices of the engineers. One engineer had created a ‘cheat sheet’, which contained recent tips for difficult service problems, and this was used as an augmentation to the manual. Engineers used the manual as a resource,

rather than as a set of instructions, and different styles of diagnosis were used at different times.

Another example, from a safety-critical domain, is Wright et al.'s (1998) study of the customisation of procedures carried out within the setting of the flight deck. They also describe the annotations made by pilots to the quick reference manual, these annotations further explaining procedures and modifying them in light of experience. Both of these studies are returned to again in Chapter 6, when the modifications to manuals and procedures witnessed in the ICU are discussed.

2.2.2 Why does customisation occur?

The 'requirements problem' is well-acknowledged (Crabtree, 2003). The 'wicked nature' (Rittel and Webber, 1973) of this problem is that it has several facets. In the development of a new technology, the people procuring the system are rarely the same people as those who will be required to use the system on a day-to-day basis (Sommerville and Sawyer, 1997). Even if potential users are consulted, they often find it difficult to define what they want from the future system and many requirements only come up once the device is in use. When there are a range of stakeholders, there is typically also a range of requirements, some of which may be conflicting, usually leading to some form of compromise in the design. As well, even if a designer was able to elicit all the current requirements, work practices change and therefore so do the requirements, meaning it will always be difficult for designers to determine all the functionality that will eventually be required of a device. As a result of this, customisation often becomes necessary. It enables users to make a system fit any newly visible requirements. This is why Moran (2002) describes customisation as 'everyday pervasive design', a form of design that 'responds to immediate problems and fixes them'.

As well as it being difficult to determine the desired functionality, it is also difficult to determine accurately the situation in which the system will be used. This is why procedures surrounding the use of a technology are often customised. For example, in Wright et al.'s (1998) study of the use of flight deck procedures, they found that the procedures were fairly simple but that to deal with a problem effectively typically requires the use of several procedures concurrently, meaning that the adherence to procedures was compromised.

There is also the important issue that different locations will have different requirements, the result of local practices and concerns. The rejection of systems due to a failure to fit with work practice is a problem that is reported again and again in the use of information technologies in a variety of domains (Button, 1993; Heath and Luff, 2000). This is why the phrase ‘localising the technology’ is often used in stories of user customisation. Berg (1997), in discussing the development and use of medical decision-support tools, has this to say about localisation:

‘In getting a tool to work, it is inescapably *localized*. Inevitably, tools that function in practice have had to give up much of the original, ideal-typed ideals about the power, range, and/or transferability of the tool. Many tools appear to work only in one specific medical practice instead of in a broad range of practices; other tools end up confining themselves to a small part of the spectrum of medical problems they may have wanted to address... The phrase “localization of a tool” points to a double meaning of the term “localization”: the tool’s projected universality diminishes, and the tool becomes more and more particular.’ (p.104)

2.2.3 Who are these customisations carried out by?

Even with single-user technologies, customisation tends to be a highly collaborative phenomenon. For example, Mackay (1990) shows how customisation occurs within social networks, describing how software customisations were shared within the organisation she studied. Gantt and Nardi (1992), in their study of CAD users, describe how collaboration allows for a greater variety of customisation than would be possible otherwise, with more experienced users assisting less experienced users. Clement (1993), in his study of the introduction of a computer system into an administrative support office, emphasises the collaborative processes used by the staff to develop and share spreadsheet templates, word processing macros, document layouts, and file naming conventions. Trigg and Bødker (1994), in their study of a governmental agency, considered how staff customised standard off-the-shelf software. Although these customisations started off as *ad hoc*, they grew more systematic in response to the requirement that such artefacts be sharable. Drawing on such examples, Dourish (2003) goes as far as to suggest that, to some extent, all customisation is collaborative.

Different categories of users have also been identified in relation to the action of customisation. MacLean et al. (1990) distinguish between the ‘worker’, who has no interest in the computer system *per se* and who has no expectation of being able to customise the system, the ‘tinkerer’, who enjoys exploring the system but may not fully understand it, and the ‘programmer’, who has formal training or extensive experience in computing. Many studies of customisation emphasise the role of ‘local experts’ in assisting the customisations (e.g. Gantt and Nardi, 1992; Trigg and Bødker, 1994).

2.2.4 How can customisation be supported?

As with studies of appropriation, studies of customisation have led to suggestions of the need to support users in making the technology their own. Because of the work that goes into making customisations, arguments have been made about the blurred boundaries between design and use and between designers and users (e.g. Trigg and Bødker, 1994; Törpel et al., 2003). It has been argued that the preoccupation of practitioners with improving design has led to a lack of concern with user-led innovation processes (Procter and Williams, 1994). Conventional systems design continues to privilege the initial design, and therefore the designer, over the subsequent use and user. For example, Suchman (1994) criticises current design approaches for their emphasis on the initial design and their lack of concern for ‘design-in-use’:

‘The prevailing order of technology production is based not in acknowledgement and cultivation of these networks but in their denial in favor of the myth of the lone (male) creator of new technology on the one hand, and the passive recipients of new technology on the other’ (p.22).

An example of an approach that is concerned with blurring the boundaries between design and use and with providing the user with more control over the system is co-realisation (Büscher et al., 2002; Hartswood et al., 2002). Drawing on the lessons of participatory design (PD), the approach emphasises a continuing cycle of design and revised work practice, taking place within the work setting, thus calling for long engagement. For example, in a three year project in a toxicology ward in a UK hospital, the use of an off-the-shelf speech recognition system was explored for assisting members of the ward psychiatric assessment team in producing discharge and transfer letters (Hartswood et al., 2000; Büscher et al., 2002; Hartswood et al., 2002). An ‘IT facilitator’ visited the ward

once a week and assisted the ward staff in using and overcoming problems with the technology, trying different technologies when necessary. Thus, part of the role of the facilitator is to facilitate the customisation desired by the users.

It has also been argued that a fruitful approach to supporting the flexible nature of work may be to provide customisable technologies. By this, we mean technologies that can be customised by the users themselves to suit each user's needs and the detail of their work (Dourish, 2003). For example, the functionality of systems can be parameterised, allowing users to configure system behaviour by selecting from lists of alternative functions (Bentley and Dourish, 1995).

Both of these approaches to supporting customisation will be explored more fully in Chapter 9, when their relevance for medical devices is considered.

2.2.5 Customisation in the medical domain

Customisation has been explored in the use of medical information systems, most notably in Berg's (1997) ethnographic study of the work necessary by practitioners in order to get decision-support tools to 'work', described above. Creating a practicable, operable tool always entails building specific contexts into the tool; as Berg states, everywhere is always somewhere. With the decision-support tools that Berg studied, the tool builder was typically a physician, who could customise the tool to fit with local practice. Certainly, this type of localisation work could be made unnecessary through changes to practice, but this would require much additional work. The changes in practice necessary when a tool developed in Leeds was introduced into a Swedish hospital were described above. Yet this approach did not always succeed; for some, the effort to adjust their practice was considered too much, and tools will always have to be tinkered with to be not too different from what practitioners are already doing and to fit with what is organisationally feasible.

Section 2.1.4 described Novek's (2002) study of the problems encountered when an automated drug distribution system was introduced into a hospital. The aspect of the system that the nurses rejected most strongly was the two hour time window for accessing drugs. The nurses were unable to customise the system but they were able to customise the procedures for using the system, so as to be able to overcome the problem of the time window. The nurses commonly overrode the machine controls in order to obtain

medication outside the standard administration time. They did this by taking advantage of a machine feature that allowed them to access a function that was designed to allow nurses access to drugs that were not yet entered onto the patient profile. The use of this function soon became standard practice.

As with appropriation, there have been few studies of customisation concerned with medical devices. We can turn to the two studies by Cook and Woods (1996) and Obradovich and Woods (1996) described above.

In the Cook and Woods (1996) study, the customisation that they identified related to the display of blood pressure. The anaesthetists found that the default display configuration for blood pressure was unsuitable for their needs. Because the absolute pressure values were not visible, different blood pressures could yield identical waveform displays. Fixed-scale graphical representation was available as a window that could be brought to the screen, overlapping the waveform display. All the blood pressures were put on this fixed-scale window, through a complex series of steps. Cook and Woods argue that through such efforts, the anaesthetists demonstrate themselves as not being ‘passive recipients of technology’ but as active in making the technology work for them.

As mentioned above, Obradovich and Woods (1996) studied nurses’ customisation of a device for the infusion of terbutaline in the treatment of preterm labour, for use by women experiencing high-risk pregnancies. As the devices were to be operated by the patient, and the nurses recognised that the patient-operators were having difficulties in operating the device and understanding the manufacturer’s manual, the nurses developed a patient guide. They also modified the procedures for using the device. For example, they told the patient-operator to change the syringe at the same time every day, rather than waiting for the syringe to run out, as was the intended procedure. This ensured that the patient-operator would not have to replace the syringe after being awakened in the night. The nurses felt that this was important because the changing of the syringe is a complex enough task even when fully awake.

2.2.6 Thesis focus: Customisation of devices in the ICU

As described above, customisation is a process that allows users to adjust the technology to both their personal needs and local practice. Examples were given above of attempts at

customising medical information technologies as part of the process of appropriation. However, there is a different level of control between the customising of medical information technologies and the customising of medical devices. Medical information technologies are often local systems. All the ICUs where fieldwork was carried out used a system for recording patient data that was developed by the Scottish Intensive Care Society and, as with Berg's (1997) decision-support tools, this system went through several adjustments, in response to users' comments and requests. In contrast, it is not likely that a nurse will reprogram a device, and certainly not easy for her to do so. As previously described, in studies of customisation, most attention has focused on information technologies outside of the medical domain.

The studies Obradovich and Woods (1996) and Cook and Woods (1996) described above were not what can be referred to as naturalistic studies, and both understandably focused on the potential threat to safety caused by such customisations. We know little about the customisation of medical devices, and about how the customisation of medical devices occurs as part of routine work. It is this gap that this thesis hopes to fill. There are various topics to be explored, such as the types of customisations carried out, who the customisations are carried out by, how the various devices currently support the nurses in making customisations, and how suggestions from the fields of HCI and CSCW for supporting customisation could be translated for the medical domain.

Safety is clearly a significant topic when considering customisations to medical devices. Therefore, an important concern for this thesis is to consider how nurses themselves deal with the concern for safety.

2.3 Workplace studies

There is a growing collection of workplace studies in HCI and CSCW that explore the social and interactional organisation of workplace activities, and the ways in which the use of technology features in everyday work and collaboration (e.g. Button, 1996; Luff et al., 2000b; Schmidt, 2000; Heath and Luff, 2000). The following definition of workplace studies comes from the preface of Luff et al.'s (2000b) edited collection of articles discussing key findings and critical issues in such studies:

‘[Workplace studies are] concerned with the ways in which new tools and technologies feature in everyday organisational conduct...They consist of ethnographies, field studies, sometimes augmented by video recordings, of work and communication in complex organisational environments...They direct attention towards the fine details of human conduct and coordination, and demonstrate how technologies...rely upon the working procedures and practical reasoning of the members of particular settings and organisations. They are concerned, in a sense, with the work to make technologies work; with the tacit and ‘seen but unnoticed’ resources through which organisational activities are accomplished in and through tools and technology.’ (p.xii-xiii)

Such studies were originally in response to the difficulties found in deploying new technologies and motivated by the belief a system could only be successfully appropriated if it adequately reflected work practice (Heath and Luff, 2000).

While the focus of such research now seems to have moved to other domains, many of the earlier workplace studies concentrated on safety-critical areas, such as air traffic control (e.g. Bentley et al., 1992b; Harper and Hughes, 1993), airport ground operations rooms (Suchman, 1993), emergency response (e.g. Pettersson et al., 2002), and rapid urban transport networks such as the London underground (e.g. Heath and Luff, 1991; 1992; 1996). Within this tradition, there have also been a large number of ethnographic studies that have considered the use of information technology in healthcare, described more fully below. There have also been studies of news rooms (Heath and Luff, 2000), manufacturing plants (e.g. Button and Harper, 1993; Auramäki et al., 1996), and law firms (e.g. Suchman, 2000), amongst others.

In most cases, such studies have been the result of collaborations between social and computer scientists. There are a variety of approaches used within workplace studies. Ethnomethodology is one analytic perspective that is commonly used to inform workplace studies, a perspective that is discussed further in Chapter 4. We also find, for example, studies informed by activity theory (e.g. Engeström, 2000) and analytic developments in cognitive science, such as course-of-action analysis (e.g. Theureau and Filippi, 2000). However, what unites these studies is a concern for qualitative data and a focus on the

detail of the setting and the work. Thus, such studies are distinct from those studies, more common in the area of human factors, which use observational methods but focus on collecting quantitative data.

2.3.1 Workplace studies of medical technology use

As well as those studies of safety-critical environments mentioned above, there have been a large number of workplace studies within healthcare. These have either been looking at current practice with the aim of designing systems that fit with the work practices of those that use them, or looking at the use of technology already in the setting, in order to consider how such systems could be improved to more closely fit with work practice. For example, Kaplan and Fitzpatrick (1997) studied remote intensive care telehealth, out of a concern to enhance doctors' and consultants' shared views of particular cases. Berg (1997), as mentioned above, studied the way in which decision-support tools were used by practitioners. Hartswood et al. (in press) explored the ways in which mammogram readers annotated the screening form, in order to develop a system to support this practice. Reddy et al. (2001; 2003) have used observational data to explore a range of issues surrounding the use of information systems in the surgical intensive care unit (SICU), including approaches for requirements analysis. Tellioglu and Wagner (2001) considered how spatial arrangements within a radiology department affected work practice.

Again, most workplace studies within medicine have focused on information technologies. However, two notable workplace studies concerned with the use of medical devices are those by Barley (1988) and Hartland (1993), both of which were discussed above.

All of these studies cover a broad range of topics and a wide range of medical specialities. However, what they all emphasise is the situated nature of medical practice, the need for flexible working practices to deal with contingencies. This aspect of medical work, and of work and action generally, will be discussed further in Chapter 3.

2.3.2 Thesis focus: Medical device use in the ICU

Clearly, there is a strong body of workplace studies concerned with technology use in medicine, including studies set within the ICU. However, as with the studies of appropriation and customisation, these studies focus on information technologies, apart from the notable exceptions mentioned above. The majority of studies concerned with

medical device use can be considered to be of a more human factors tradition, such as those by Obradovich and Woods (1996) and Cook and Woods (1996). Such studies typically lack the concern for detail that distinguishes workplace studies. The result of this is that we know little about the practices surrounding the use of medical devices. As technology moves increasingly away from the desktop to devices embedded within the environment, and as in these products the interfaces are often physical objects not screens, it is necessary that the focus of such studies make a similar move (Wensveen et al., 2000).

2.4 Research domain

The chapter so far has distinguished the research presented in this thesis from other research dealing with similar issues and taking a similar methodological approach. What largely distinguishes this thesis is its focus on the setting of intensive care and its concern with medical devices, rather than information technologies used within medicine. Therefore, it seems appropriate to give some background to the setting of the ICU and some detail about the technologies used within that environment.

2.4.1 Intensive care

This thesis is concerned with the appropriation and customisation of technologies used within the intensive care unit. Intensive care is quite different to other areas of secondary care and therefore it seems worthwhile to briefly give some detail about the setting. The primary goal of ICU staff is to stabilise patients so that they can be safely transferred out of the unit, typically to a high dependency unit (HDU).

An important aspect of the ICU is that patients are grouped by the severity of the illness and the criticality of the physiological state, rather than being grouped by type of illness. This means that ICU staff see a wide variety of patients. Many patients will be post-operative patients, whose operation has gone according to plan but who are in a critical state as a result of the operation. ICUs typically also see a large number of alcohol and drug abusers, and patients who have come in from accident and emergency, such as car crash victims and suicide attempts. Therefore, staff are required to carry out many diverse activities in the provision of care. Regular nursing tasks include noting hourly patient physiological data, ensuring a continuous delivery of the necessary drugs, and washing the patient. The state of the patient can very quickly change and must be carefully monitored.

Nursing tasks often also involve providing technology-focused treatments and they may be required to manage several technology-focused treatments at one time.

The emotional state of patients can also vary greatly. In some cases, patients may be essentially paralysed due to muscle relaxant drugs, heavily sedated, or already comatose because of a drug overdose, trauma, or severe illness. Other patients may be conscious yet too weak to talk, while some patients are awake and chatty. Patients may be confused or aggressive. Thus, the amount and nature of emotional work that staff have to do varies greatly. Because of the critical state of patients, nurses are frequently in communication with relatives, updating them about the state of the patient, as well as providing important emotional comfort.

Intensive care is quite different from other areas of medicine in terms of the organisation of staffing. There is always one consultant on duty, who will typically do two ward rounds a day, one in the morning and one in the afternoon. The consultant may be absent from the unit for much of the time, although he will be elsewhere in the hospital. A senior house officer (SHO) will also be on duty and will be on the unit for much of the day. While patients will be seen by whichever consultant is on duty, patients will be looked after by the same nurses, as far as is possible. Because of the considerable nursing input required by critically ill patients and their relatives, the staff patient ratio has increased over the years, so that on both day shifts and night shifts, there is now one nurse per patient, as well as a charge nurse who oversees the unit, in line with the UK Intensive Care Society (1983) guidelines. The wards are also much smaller than general wards; the median size of a ICU in the UK is 5.3 beds (Ridley and Dixon, 2003).

Because the nurse has much greater contact with the patient, intensive care nurses have a higher level of autonomy than in other areas of nursing. Nursing is very much a female dominated profession. However, although still remaining largely staffed by women, intensive care units do tend to attract more male nurses than most other areas of medicine. Intensive care units also have a reputation for encouraging continuing education more than general wards. For example, nurses often pursue a Diploma in Critical Care on a part-time basis.

2.4.2 Intensive care equipment

Intensive care can be thought of as a ‘machine-rich’ environment (Strauss et al., 1985). As a result of the significance of machines within this setting, the use of technology has been identified as being an important part of intensive care nursing, one of the ways in which it distinguishes itself from other areas of nursing (Alasad, 2002).

There is a wide range of complex devices used within the ICU in order to monitor and treat the patient. Each patient will typically be attached to the following:

- A vital signs monitor, which is a microprocessor-based physiological monitoring system, similar in shape and size to a television. It continuously displays different wave forms on the screen, representing the patient’s heart rate, blood pressure, central venous pressure, and pulse oximetry saturation (see Figure 2.2. below);
- A ventilator, which assists the patient’s breathing;
- An enteral nutrition pump, which delivers food to the patient’s stomach, via a tube through the nose; and
- Around two to six syringe drivers, delivering drugs to the patient at a steady rate (see Figure 2.3 below).

There may also be other pieces of equipment that are particular to the patient’s needs, such as a device for dialysis. All of these devices are placed around the patient, as shown in Figure 2.1 below.

Amongst other differentiating properties, the different pieces of equipment vary in terms of size, cost, skill required to operate, ease of operation, reliability, and attention required from nursing staff when operating (Strauss et al., 1985). Naturally, these properties affect the work done with and around different devices – the care taken, the time spent setting up the device, the effort given to monitoring the device.

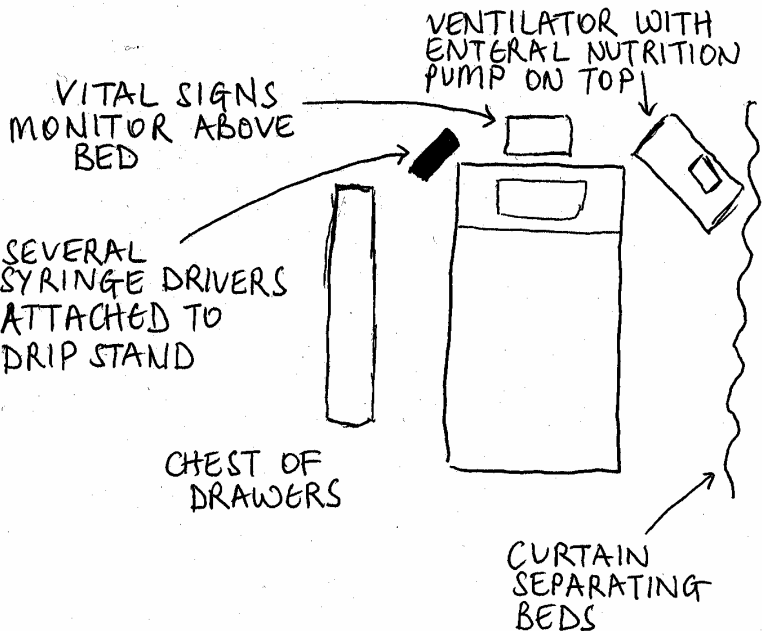


Figure 2.1: A drawing of the typical layout of equipment around the bed

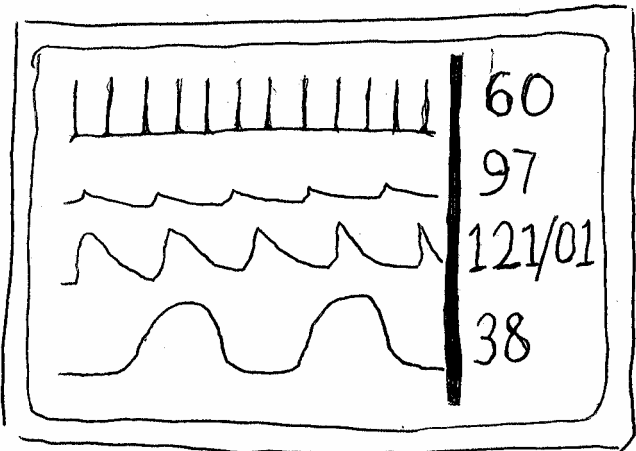


Figure 2.2: A drawing of a typical vital signs monitor

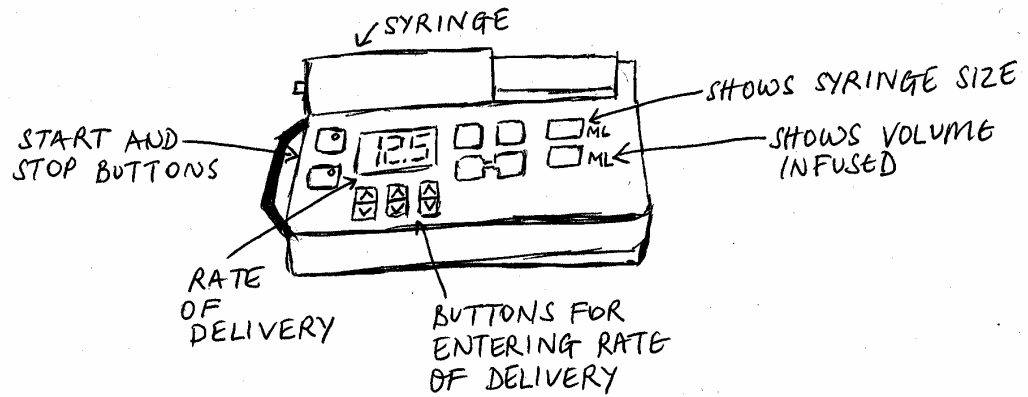


Figure 2.3: A drawing of a typical syringe driver

Despite the importance of technology in the ICU and the importance placed on technology use as part of intensive care nursing, before beginning her employment in an ICU, a nurse will typically have received little or no instruction in the devices she has to use, developing the necessary skills on the ward. This was the case in the units where observations were carried out but a similar lack of training is described by Strauss et al. (1985) and Alasad (2002). Because of a lack of standardisation in medical equipment, when an agency nurse comes to the unit, it is usually necessary for a member of staff to explain certain pieces of equipment.

2.5 Summary

This chapter has described the three main areas of research that this thesis draws on and contributes to: studies of the appropriation of technology, studies of the customisation of technology, and workplace studies generally. This chapter has also described the setting with which this research is concerned, the ICU. From this, it is now possible to further specify the main research questions of this thesis:

What work practices surround and support the appropriation and customisation of medical devices by nursing staff?

- a. What are the main difficulties of appropriation?
- b. What types of customisation occur and how are they carried out?
- c. Why does customisation occur?

- d. Is customisation a collaborative activity within the ICU, as it has been found to be in other settings?
- e. What distinguishes the practice of customisation as it is observed in the ICU from customisation as it is generally described in the HCI and CSCW literature?
- f. How are concerns for safety dealt with?

To what extent should we be supporting the customisation of medical devices by nursing staff and how can we support it?

- a. What are the various means by which medical devices currently support the nurses in making customisations?
- b. What other means for supporting customisation of medical devices are suggested by the nurses' practices?
- c. If greater customisation was supported, how could safety be ensured?

Having further specified the research questions, the following chapter goes on to describe the theoretical context for this research. Two assumptions about the nature of human action and interaction, that are argued to be important to our understanding of technology appropriation and customisation, are described and their relevance for the research questions defined.

Chapter 3 – Theoretical context

The previous chapter set the work presented in this thesis within the context of previous studies of appropriation and customisation. The aim of this chapter is to provide the theoretical context for the research. It is the contention of this thesis that two concepts, two assumptions about the nature of human action and interaction, are important to our understanding of technology appropriation and customisation. Two concepts from an ethnomethodological perspective are used.

The first concept is the ethnomethodological conception of accountability (Garfinkel, 1967). Ethnomethodologists are concerned with the accountability that we feel to colleagues, friends, and family. We can refer to such accountabilities as local accountabilities, in contrast to the more formal accountabilities that we have in relation to employers and the like. Wenger (1998) uses the term mutual accountability. It is ethnomethodology's contention that what it means to be a member of a community is to share a set of local, contextual understandings of how to act, and how to understand action, within that community. It is the contention of this thesis that local understandings of accountability affect the use of technology, and the use of technology in turn affects those local understandings of accountability. Therefore, this conception of accountability is important in considering the appropriation and customisation of medical devices within the ICU, because it encourages us to consider not only the nurses' formal accountabilities but also the local accountabilities that encourage them to customise and persist with the technology.

The second concept is the notion of situated action (Suchman, 1987). The notion of situated action considers that every course of action depends in essential ways upon its material and social circumstances. This is an idea that has received much attention within the fields of HCI and CSCW. It is important in considering the appropriation and customisation of medical devices within the ICU, because it provides a means to understand users' attempts to customise the procedures that surround various technologies and to overcome the procedures that are inscribed within them. It also emphasises the importance of local needs and the importance of understanding local practice for design.

Below, these two concepts and their relevance for the research questions of this thesis are further defined.

3.1 Accountability

Accountability is a topic that has received much attention, within academic, institutional, and public discourses. Demands for accountability are not new and discussion of such topics goes back to early philosophical concerns about how to restrain power, prevent abuses of power, and keep the behaviour of those in power in line with established rules (Day and Klein, 1987). The common usage of the term ‘accountability’ suggests similar concerns. The Oxford Dictionary of English (2003) provides the following definition of the word ‘accountable’:

Accountable *adj* **1** Liable to be called to account, or to answer for responsibilities and conduct; answerable, responsible. Chiefly of persons.

There is currently a growing demand for public services, and those that work within them, to be held publicly accountable. Doctors, nurses, teachers, university lecturers, police officers and social workers are all examples of professions that are being put under increased pressure to record what they do and for these records to be open for inspection; there has been an ‘audit explosion’ (Power, 1997). This is particularly true in the UK National Health Service, following on from high profile cases such as the Harold Shipman case (Chief Medical Officer, 2001) and the ‘Bristol Babies Inquiry’ (Bristol Royal Infirmary Inquiry, 2001).

3.1.1 Local accountability

A concern with accountability can be considered as a fundamental feature of the ethnomethodological perspective (Lynch, 1993). Ethnomethodology is a field of sociology that originated with the work of two sociologists, Harold Garfinkel and Harvey Sacks, in the late 1940s and 1950s. The concept of accountability described above is concerned with relations of accountability between employees and their managers, employers, or regulatory bodies. Yet an important form of accountability is the accountability that we feel to colleagues, friends, family, to the ‘communities of practice’ (Wenger, 1998) of which we are all members. We can refer to such accountabilities as local accountabilities, in contrast to the more formal accountabilities that we have in relation to employers and

the like. This is what Wenger (1998) refers to as ‘mutual accountability’. It is this accountability, accountability to ‘members’ rather than ‘others’, which is of interest to ethnomethodologists.

It is ethnomethodology’s contention that what it means to be a member of a community is to share a set of local, contextual understandings of how to act, and how to understand action, within that community (Garfinkel, 1967; see also Strong, 1979; Wenger, 1998). A key concept is the notion of action as ‘observable-and-reportable’: other members can observe and report, that is, make sense of, the action in the context in which it arises (Lynch, 1993). By acting in accordance with such understandings, they demonstrate themselves as being competent members of that community. Through their common orientation towards and participation in activities, communities of practice share not only histories, but also a shared system of meaning and values (Wenger, 1998). This notion of accountability moves away from more traditional conceptions of accountability, of being able to account for our actions. Instead it focuses on the expectations that affect our behaviour within our communities.

An example of such accountability is at a ‘social occasion’, where one is to be on display and therefore hopefully on their ‘best behaviour’. Before the event, we want to know what the ‘rules’ are: what we should wear; what to bring; what conversation topics to avoid. Strong (1979) argues that all social intercourse shares these qualities, although not necessarily to such a self-conscious degree. We routinely make judgements about the character and competence of others based on their actions and they in turn judge us.

Even when alone, we are acting in accordance with local relations of accountability. For example, when preparing a meal for friends who will arrive later, our preparations are shaped by those relations, by what is considered within that particular community of practice to be a ‘competent’ dinner party. Wenger (1998) gives the example of an academic preparing a conference presentation. Although alone, relations of accountability to the academic community are strongly felt, shaping the style and the content of the presentation.

Thus, for ethnomethodologists, accountability is a pervasive feature of how people coordinate their actions:

‘[The] central recommendation [of ethnomethodological studies] is that the activities whereby members produce and manage settings of organized everyday affairs are identical with members’ procedures for making those settings “account-able.” [...] When I speak of accountable, my interests are directed to such matters as the following. I mean observable-and-reportable, i.e. available to members as situated practices of looking-and-telling. I mean, too, that such practices consist of an endless, ongoing, contingent accomplishment: that they are carried on under the auspices of, and are made to happen as events in, the same ordinary affairs that in organizing they describe; that the practices are done by parties to those settings whose skill with, knowledge of, and entitlement to the detailed work of that accomplishment – whose competence – they obstinately depend upon, recognize, use and take for granted; and *that* they take their competence for granted furnishes parties with a setting’s distinguishing and particular features, and of course it furnishes them as well as resources, troubles, projects and the rest.’ (Garfinkel, 1967, p.1-2)

Garfinkel’s study of jurors’ deliberations, the study which can be considered as the first ethnomethodological study, asked the question ‘What makes them jurors?’ (Garfinkel, 1974). Not only that, but what makes them ‘good jurors’; what does a ‘good juror’ pay attention to? By this, Garfinkel did not mean what a judge or a member of the public would consider a ‘good juror’, but what the jurors themselves considered to be ‘good jurors’ (Garfinkel, 1967). The ‘rules’ for being a good juror that Garfinkel lists are rules that the jurors themselves talked about, what they accepted and came to expect from themselves and each other. Thus, a concern for members’ methods means a concern for what members consider to be, and recognise as, appropriate methods for members:

‘When I talk about the accountable character of affairs or when I talk about accounts, I am talking about the availability to a member of any ordinary arrangement of a set of located practices.’ (Garfinkel, 1974, p.17)

A more recent example of such studies is Laurier et al.'s (2001) exploration of how café customers accomplish 'doing being customers', the particular rights and obligations that go along with that identity and the unwritten yet visually displayed codes of conduct.

Such relations of accountability do not occur only within workplaces or units such as 'jury', 'family', 'regulars'. These relations of accountability may arise among temporary units, as demonstrated in Murtagh's (2001) consideration of train passengers' use of mobile phones. Murtagh describes, for example, how a phone that goes unanswered is 'a morally accountable phenomenon', made evident by the facial gestures and the direction of gaze of others in the train carriage. He goes on:

'Like a question, the ringing of a phone is designed to solicit a response from the other. Where that response is not forthcoming it is made accountable by the caller (who awaits the answer) and also, in this instance, by those co-present who display, through gaze and bodily movement, the expectation to answer somebody's call'. (p.87)

What this also points to is the way in which such local accountabilities actually become most apparent when members fail to act in accordance with them (Garfinkel, 1967).

Such relations of accountability also extend beyond one particular geographical location or community, demonstrated in Laurier et al.'s (2002) exploration of what it means to be a neighbour and how we demonstrate ourselves as good neighbours. Thus, another important aspect of the ethnomethodological notion of accountability, which is the greatest difference from common notions of accountability, is the idea that the accountable aspect of an activity is an inherent and inseparable feature of how the activity is woven into action and interaction, rather than being a commentary on the activity, standing separately from it.

This notion of accountability makes a move away from notions of rules, policies and standards. In contrast to more formal accountabilities, such as our accountabilities to our employer, such local accountability is often not explicitly defined. Such understandings of accountability may also be difficult to articulate because they are such an integral part of the practice (Wenger, 1998). Local accountability is also rather flexible, there often being many different ways in which such accountabilities can be interpreted (Strong, 1979). A

relation of accountability provides only a guideline for the overt form of actions, not a detailed prescription. For example, to return to Murtagh's (2001) study of mobile phone use on trains, what is considered an acceptable call length is dependent on a variety of contextual factors, such as the time of day and the topic of conversation. Thus, the time of day and the topic of conversation become 'resource[s] available to members to constitute a response to mobile phone use' (p.89).

It has previously been noted that those who work at the 'sharp end' in safety-critical settings often face a variety of difficulties, complexities, dilemmas and trade-offs, and are called upon to achieve multiple, often conflicting, goals (Woods and Cook, 2002; Symon et al., 1996). There may be conflicting accountabilities, particularly between 'official' and 'unofficial' accountabilities (Strong, 1979; Yakel, 2001). Official accountabilities may conflict with local practice or be moulded into localised practice that is far removed from related written standards, procedures and professional 'best practice' (see Orlikowski (2002) for a discussion of the difficulties of the notion of 'best practice'). Certainly, within a work environment, professional definitions of accountability do affect local understandings of accountability, but they are not the same. For example, while the UK Central Council for Nursing, Midwifery and Health Visiting defines what it means to be a good nurse, understandings within a particular ward will be more specific, not necessarily contradicting the UKCC definition but linking it to the specific setting, context, and situation.

While ethnomethodological studies of accountability are typically concerned with accountability within a community, it seems worthwhile to mention a couple of studies that have used the ethnomethodological notion of accountability to explore organisational accountability. Luff and Heath (1993) show how the work of an architectural practice is oriented to a range of individuals and organisations outside of the architectural practice itself, such as structural engineers, drainage engineers, building contractors, fire officers, and clients. Button and Sharrock (1998) use the ethnomethodological notion of accountability to explore how software developers demonstrate their work to be work-as-it-is-done-within-the-organisation. Such studies draw our attention to the fact that, both with accountability to 'others' and accountability to 'members', accountability is an inherent and inseparable feature of our activities.

3.1.2 Accountability and technology use

The ethnomethodological notion of accountability has been receiving growing attention within the fields of HCI and CSCW. While much of that has been as part of workplace studies such as those mentioned above (e.g. Luff and Heath, 1993; Button and Sharrock, 1998), there is now a move to consider the notion of local accountability more generally, to consider its significance for design (Dourish, 1995; 2001; Eriksén, 2002). Work that has come out of ethnomethodological notions of accountability has focused on the role that accounts of action play in enabling interaction, providing others with the means to understand the action and how to respond. For example, Dourish (1995; 2001) has explored the way in which systems can provide accounts of their actions to users, so as to support user interaction with the system, moving attention ‘away from simply the perceived result or outcome of an action, to include how that result is achieved’ (Dourish, 2001, p.80). However, this approach focuses on the system’s accountability to the user, which seems to move away from the notion of local accountability, being concerned with accountability to ‘others’ rather than accountability to ‘members’.

What has not been adequately explored to date is how local accountability affects technology use. It is the contention of this thesis that local understandings of accountability affect the use of technology, and the use of technology in turn affects those local understandings of accountability. The introduction of technology creates new opportunities for demonstrating competence, while removing others. It is part of the reciprocal nature of the appropriation of technology (Bikson and Eveland, 1996).

For example, in the domestic setting, Ribak (2001) describes how personal computers create new understandings of competence, which may conflict with traditional hierarchies within the home. Within the workplace, the widespread use of electronic mail has had great significance for relations of accountability. Responses to emails are expected much more quickly than responses to letters, but at the same time, a level of informality has become acceptable that would not be considered appropriate for a written business letter (Sproull and Kiesler, 1991). Within medicine, the introduction of a whole host of new information technologies has had a profound impact on the collection, analysis and dissemination of information, providing resources through which new forms of accountability have evolved (Heath et al., 2003). McCarthy et al. (1997) have argued that the requirements for the design of high-consequence work systems should be informed by understanding both local

accountabilities and more formal accountabilities and the conflicts that arise between them. It was out of concern for maintaining methods for accountability when installing an electronic system that Hartswood et al. (in press) observed how mammogram readers demonstrated their competence through form filling procedures.

In relation to the subject of this thesis, possible areas to be explored include how the introduction of technology has affected understandings of accountability within the intensive care unit and how understandings of accountability have affected technology use, particularly how such understandings affect the appropriation and customisation of technology.

3.2 Situated Action

The best way to plan is carefully to write everything down on a piece of paper and then to rip the paper to shreds. This accurately reflects what happens to plans in real life... Most people do their planning after the event. This is a lot easier, because you know exactly what happened and can come up with a very impressive plan that would have made you look terrific had you actually done any of it.

- How to...plan, *The Guardian*, 26 April 2003

Previous workplace studies of the medical domain have emphasised the situated nature of medical work and the need to manage contingencies (Symon et al., 1996; Bardram, 2000; Hartswood et al., 2003a). Within medical settings, work is typically organised and coordinated through a combination of formal procedures and what Strauss et al. (1985) refer to as 'less formalized, institutionalized and perhaps less immediately visible modes of action' (p.190). These less formal procedures are often developed in order to deal with local contingencies. Therefore, while similar formal procedures may be identified in different organisations, informal practices are context-specific and vary from location to location.

However, ethnomethodologists treat all work, in fact all action, as inherently situated (Garfinkel, 1967; Suchman, 1987). Such a balance between formalised procedures and local practice has been identified in a variety of domains of work, including the police force (Benson, 1993), air traffic control (Harper and Hughes, 1993), and manufacturing (Button and Harper, 1993).

This view of action is in direct contrast to the traditional cognitive science view of action, which considers human action to be essentially goal-oriented and plan-based. Ethnomethodologists are willing to concede that humans do plan and that such plans act as resources for action, but they do not consider that plans determine the course of action in any strong sense. Typically, our stated intentions do not address the question of situated action at any level of detail (Suchman, 1987). Because the relation of the intention to the actual course of situated action is enormously contingent, a statement of intent generally says very little about the action that follows. It can be argued that plans and goals do not provide the solution to a problem but rather that they re-state the problem.

Suchman (1987) argues that the confusion over the status of plans arises from the fact that, in our everyday descriptions of action, we tend not to distinguish between those accounts provided before and after the fact, and the action's actual course. Garfinkel (1967) argues that when action is proceeding smoothly, it is essentially transparent to us, like Heidegger's (1962) notion of equipment that is 'ready-to-hand'. It is only when such activity becomes in some way problematic that our actions may become explicitly goal-oriented:

‘As common-sense constructs, plans are a constituent of practical action, but they are constituent as an artefact of our *reasoning about* action, not as the generative *mechanism of* action. Our imagined projections and our retrospective reconstructions are the principal means by which we catch hold of situated action and reason about it, while situated action itself, in contrast, is essentially transparent to us as actors.’ (Garfinkel, 1967, p.38-39)

This viewpoint considers that we generally do not anticipate alternative courses of action and their consequences until some course of action is already under way. This is partly due to the fact that it is often only when acting in the situation that its possibilities become clear, and we often do not know, apart from a vague sense, what future state we wish to bring about, hence the ethnomethodologists' objection to the view of action as goal-based. Ethnomethodologists point to the typically vague and flexible nature of goals. Garfinkel (1967) argues that in many situations it is only when we encounter a state of affairs that we consider to be desirable that we identify the state as the goal towards which our previous

actions were directed “all along” (p.98). As will become apparent in the following chapters, not only is the plan for action often unclear in the medical domain, but the goal to which the plan is directed may be unclear or subject to ongoing change as the situation develops. The task that the nurses see before them is getting through the day in an acceptable, or preferably convenient, way, and what this means and involves changes from day to day and moment to moment, largely dependent on the state of the patient.

This view of action clearly has significance for the role of formal procedures and rules. Ethnomethodologists hold that, as a consequence of the indexicality of language, an instruction’s meaning, its significance with respect to action, is not inherent to the instruction itself. Rather, the instruction’s meaning must be found with reference to the situation of use. Garfinkel (1967) argues that instructions unavoidably depend upon an implicit *et cetera* clause in order to be called complete:

‘To treat instructions as though *ad hoc* features in their use was a nuisance, or to treat their presence as grounds for complaining about the incompleteness of instructions, is very much like complaining that if the walls of a building were gotten out of the way, one could see better what was keeping the roof up.’ (p.22)

Following on from the view that action only becomes goal-based when an activity becomes problematic, it holds that the rules and procedures that come into play when we deal with problems are not self-contained but rather are contingent and derived from the situated action that the rules and procedures represent.

3.2.1 Situated action and technology use

Although based on the ideas of Garfinkel, the term *situated action* in fact comes from Suchman’s (1987) critique of the planning model of artificial intelligence. Although there had long been a general sociological interest in interactive technology, the publication of *Plans and Situated Actions* was a decisive turning point for the role of sociology in HCI (Dourish, 2001). In focusing on ‘the problem of human-machine communication’, Suchman’s work led to a fundamental reassessment of the benefits that sociology could bring to the development and analysis of interactive systems. Her observation is that the planning model was the basis of the design of interactive devices. Interaction models

assumed that users' actions were goal-oriented and plan-based. They treated features of the world, and our interaction with it, as stable, objective phenomena, allowing relatively unproblematic execution of a plan around these phenomena.

Suchman's (1987) view was that these apparently objective phenomena were in fact active interpretations of the world formed in response to particular events occurring within specific contexts; the sequential organisation of behaviour is an ongoing, improvised activity. Our actions are organised in response to features of the setting in which they arise; hence, the notion that our actions are situated. Suchman states that the term 'underscores the view that every course of action depends in essential ways upon its material and social circumstances' (p.50). The contingency of action on a complex world of objects and actors, located in space and time, is no longer treated as an extraneous problem with which the actor must contend. Rather, it is seen as the essential resource that gives action its sense.

3.2.2 Situated action and customisation

This notion of situated action has received much attention within the fields of HCI and CSCW. Structures such as procedures are found in the majority of organisations and some of these structures are incorporated into the technology. These structures may be simply reproduced within the technology or they may be modified or combined with manual procedures, thus creating new structures within and around the technology (DeSanctis and Poole, 1994). The notion of situated action has been used as a means to understand and explain the many *workarounds* that are identified in workplace studies, as users attempt to customise the procedures that surround the technology and to overcome the procedures that are inscribed within it. For example, there is Wright et al.'s (1998) study of customisation of procedures within the setting of the flight deck. As described in the previous chapter, procedures are customised in light of previous experience and the need to use several procedures concurrently can mean that the adherence to procedures is compromised.

Another example comes from Button and Harper's (1993) case study of a manufacturing firm. There, the process of ordering, manufacturing and invoicing was not done according to the record but was instead carried out in relation to local circumstances. Although the process appeared to be sequential, with orders preceding manufacture and manufacture resulting in an invoice, in reality this was often not the case. For example, sometimes telephone orders would go directly to the first line of production workers, rather than the

front office. Manufacture would then begin before an order was processed by the front office and before an order form has actually been issued. Often, an item would be in production before being priced and the price accepted. A computer system was introduced which reflected the formalised process and thus required the activities of ordering, manufacturing and invoicing to be carried out in a sequential process. As Button and Harper argue:

‘The model implicit in the system necessarily stripped the work practices of ordering, manufacturing and invoicing of their situated details and dislocated these processes from their organisational context.’ (p.99)

In response to the introduction of this system, the employees found ways to work around the system, in order for them to carry out what was in fact considered by those in the setting to be ‘good working practice’.

In the medical domain, Symon et al. (1996) describe a variety of deviations from the formal procedures surrounding radiological examination, such as the processing of incomplete request forms and failures to complete report forms. Such deviations from procedures are seen as responses to local contingencies and an essential aspect of all human work and behaviour. Procedures and instructions are seen as resources for action, being ‘made to work’ in a particular setting and situation, rather than being prescriptions for action in any strong sense.

The notion of situated action also helps to understand why the procedures surrounding technology can never be satisfactory on their own. Within the setting of air traffic control, Harper and Hughes (1993) argue that not only there are many procedures and local rules that are not described in the *Manual of Air Traffic Services* but that they could not be, because they are based upon individual and local ‘learnt through experience’ knowledge and are tacit features of the work.

As well as helping to explain why users will often reject systems that are too strongly inscribed with formal procedures that are not adhered to, the notion of situated action also emphasises the importance of local needs and the importance of understanding local practice for design. Local needs and local work practices mean that a system that is

accepted in one location will not necessarily be successful elsewhere. For example, Strauss et al. (1985) provide the example of a hospital where efforts were made by the hospital administration to standardise cardiovascular monitors for all the ICUs. However, consensus could not be reached as to what was the best model, because each unit felt that its clinical needs were unique and could not be met by using a single product.

In relation to the subject of this thesis, possible areas to be explored include how nurses respond to contingencies through the use of technology and how local practices and needs are reflected in the use of technology, including its appropriation and customisation.

3.3 Summary

This chapter has described two concepts that it has been argued are important for understanding the appropriation and customisation of technology. What this view suggests is that medical work, including interaction with technology in medical settings, is both a situated accomplishment and an accomplishment that is defined in relation to local, situated understandings of accountability.

While nurses in many areas of nursing do not have much autonomy, as was noted in the introductory chapter, intensive care nurses are given a much greater degree of autonomy. Without autonomy, notions of formal accountability have little significance, but as the level of autonomy increases, so does the requirement for formal accountability. The central chapters of this thesis explore how the introduction of technology has affected the situated, local understandings of accountability within the intensive care unit and how understandings of accountability have affected technology use, particularly how such understandings affect the appropriation and customisation of technology. The research problem is not to find a way of reconciling this accountability with the demand for formal accountability, but rather to ask how medical workers are currently managing to reconcile these two views of accountability.

The central chapters of this thesis will also draw on the notion of situated action in order to explore how nurses respond to contingencies through the use of technology and how local practices and needs are reflected in the use of technology, including its appropriation and customisation.

Chapter 4 – Methodology

Having now described the fields of research to which this thesis hopes to contribute, and having described the notions of local accountability and situated action on which this thesis draws, this chapter describes the methodology used in this thesis for the collection and analysis of data.

The chapter begins by considering the different research methods that could have been used for this study. The limitations of such methods led to a decision to use ethnography as the means for collecting data. Therefore, an introduction to ethnography is provided, before considering how ethnographic approaches have been used in the study of technology, particularly within HCI and CSCW. The methodological approach used in this thesis is then outlined. Different approaches to the analysis of ethnographic data are then described. Finally, the issue of how to validate the analysis is examined.

4.1 Possible research methods

The introductory chapter of this thesis defined one of the objectives of the research as being to gain a detailed understanding of how nurses appropriate equipment through the practice of customisation, including an understanding of the work practices that surround and support such customisation. In fact, the initial research objective was broader than that. The initial research objective was to gain a detailed understanding of how nurses use equipment within the ICU, appropriation and customisation being topics that emerged within the process of the research. One of the motivations for this research was that there is much information on issues of error in the use of medical devices (e.g. Cook and Woods, 1994; Senders, 1994) but there is little information on the everyday use of medical devices. In order to gather information on the use of equipment within the ICU, several possible methods could be used, some of which were used in the early stages of this research.

4.1.1 Interviews

One possible qualitative approach is the use of interviews. Interviews could be carried out with nurses at several units, and this would possibly allow access to more units than is possible with more time-consuming approaches such as ethnography. However, the first key limitation of interviews for the purpose of this research is that the information gathered is limited by the questions asked, and the questions asked are limited by the (possibly

incorrect) assumptions of the researcher. This reduces the chances of discovering evidence discrepant with those assumptions (Hammersley, 1995). Prior to observing at the unit where the eight week study was carried out, interviews were carried out with the ward manager and two other senior nurses. Appropriation and customisation were not topics that came up, because they had not been identified as potential topics for questions.

A second limitation of interview data is that it misses the difference between what people say and what people actually do. In the initial interviews with nurses in the unit, the picture presented of technology use in the ICU was very much ‘technology use in the ICU as it is meant to be’. When later carrying out observations in the unit, it was found that there were many deviations from that initial picture that was presented during the interviews. This difference between what people say and what people do is particularly important when concerned with issues of local accountability. Even where local understandings of accountability are accurately recounted, it is impossible to determine how such understandings relate to actual behaviour, how those understandings are applied (Strong, 1979).

More generally, it has been argued that the consideration of technology must be carried out within the larger context of its use (Silverstone, 1994). As studies of technology appropriation show, technology is deeply intertwined with everyday life, with technology use influencing and being influenced by numerous context dependent conditions, meaning that quantitative data is of limited use (Huysman et al., 2003). If we ignore the detail of everyday life, the social, we potentially lose much useful understanding of the technology as well.

4.1.2 Questionnaires

A potential quantitative approach was the use of questionnaires. However, this approach faces many of the same limitations as interviews. Using questionnaires, the information gathered is limited by the questions asked, and the questions asked are limited by the assumptions of the researcher. Again, this approach misses the difference between what people say and what they actually do, and fails to consider technology within the larger context of its use.

4.1.3 Experimental studies

An approach which fits more closely with traditional approaches within HCI would be to use an approach such as that used by Cook and Woods (1996) in the study described in Chapter 2, or to use an approach such as that used in previous work by Cook and Woods (1994). This work draws on observational data and on accounts of previous critical incidents, but uses concepts from cognitive science to understand the data and uses the data to identify cognitive factors and cognitive activities that affect behaviour. Our understanding of technology use has been much influenced by cognitive science. In HCI, studies of computer use were traditionally experimental and aimed at developing cognitive models of user's activities, and this experimental tradition persists (Heath et al., 2000).

However, studies which focus on specific cognitive behaviours can miss the situated nature of action (Suchman, 1987). What too often becomes bracketed as 'cognition' is in fact a complex social phenomenon (Lave, 1988; Wenger, 1998). It has been argued that when 'cognition' is observed in everyday practice, it can be seen as being stretched over mind, body, activity, and culturally organised settings, including other actors. Making claims about what happens in 'natural' settings on the basis of data produced in settings specially set up by the researcher leads to invalid generalisations. Again, such an approach fails to consider technology within the larger context of its use.

4.1.4 Critical incident reports

Another possible approach was to gather information by looking at critical incident reports. This is an approach that has been used in various studies of safety-critical domains (e.g. Reason, 1997), including the medical domain (e.g. Webb et al., 1993; Reason, 1995; Vincent et al., 2000). In the early stages of this research, the critical incident reports of one unit were considered, resulting in a workshop paper (Randell et al., 2001).

However, there are several problems associated with the use of critical incident reports. Firstly, there are a range of practical problems. Within medicine, there have been many difficulties in getting staff to complete critical incident forms (Pietro et al., 2000). In the unit where the critical incident reports were studied, it was acknowledged by the ward management that the recording of critical incidents regularly did not occur. Therefore, critical incident reports do not necessarily give an accurate picture of all that is happening in the unit. The fact that most critical incident reporting schemes are anonymous. This

means that it is not possible to gather further information about a critical incident. There is also the issue that much of the appropriating and customising of devices that this thesis describes, although consequential for safety, are not seen as critical incidents and therefore are not recorded in the critical incident reports. As well, at the time of starting this research, there was no single focal point for NHS information on critical incidents, with such information being spread across nearly 1,000 different organisations (Chief Medical Officer, 2000). Some hospitals had implemented their own incident reporting schemes, while in other hospitals it was only certain departments that had an incident reporting scheme.

Another problem with using critical incident reports is that it puts the focus on error. As described above, one of the motivations for the research was that there is much information on issues of error in the use of medical devices but there is little information on the everyday use of medical devices. Therefore, using critical incident reports to gather data would not redress this balance and would not provide information on the everyday day use of medical devices within the ICU.

4.1.5 Ethnography

In order to fulfil the initial research objective of gaining a detailed understanding of how nurses use equipment within the ICU, an ethnographic approach was taken for the collection of data. Ethnography is a broad approach to the study of people in their environments, where the researcher participates in the setting in order to collect data.

There are several advantages of using ethnography over the other possible methods described above. Firstly, and most significantly for the results of this research, the research is not limited by the researcher's assumptions to such a significant extent. Secondly, rather than relying on what people say they do, ethnography looks at what people actually do. Thirdly, the researcher is present at the fieldwork site for an extended period, providing the opportunity not only to observe the behaviour of those in the setting, but also allowing for discussion about their thoughts and feelings in the course of ongoing events. Finally, the setting is witnessed over a significant period of time, as opposed to making claims on the basis of data that reflect only some aspects of what goes on in the setting. This leads to more detailed data and avoids generalisations, moving away from abstract theory.

As with any methodology, there are limitations to ethnography. One criticism of ethnography is with regard to the issue of representation (Hammersley, 1992). To what degree can ethnographic accounts legitimately claim to represent an independent social reality? Critics argue that ethnographic accounts are subjectivist and relativistic. Realism is the idea that there is a reality independent of the researcher whose nature can be known, and that the aim of research is to produce accounts that respond to that reality. Constructivism, on the other hand, is the idea that people construct the social world, both through their interpretations of it and through their actions based on those interpretations. The data which ethnographers use is a product of their participation and is constructed in and through the process of analysis and the writing of ethnographic accounts. Yet this is true of all research methods that attempt to analyse results: analysis is interpretation. All descriptions are theoretical in the sense that they involve concepts and are structured by theoretical assumptions. Hammersley (1992) proposes a more ‘subtle’ form of realism, whereby knowledge is defined as beliefs about whose validity we are reasonably confident. Such ambiguity is acceptable on the basis that we can never be completely confident of descriptions of social phenomena because there is no direct access to reality; we are prevented by the barriers of our own preconceptions, understanding and language. This form of realism considers that there are phenomena independent of our claims about them that those claims may represent more or less accurately. However, it acknowledges that representation must always be from some point of view that makes some features of the phenomena represented relevant and others irrelevant. The solution is not to disregard ethnography but to be aware of, and declare, potential bias (Hammersley and Atkinson, 1995). This topic is returned to in Section 4.7 with the discussion of techniques for validation.

Ethnography has also been criticised for its failure to directly influence practice (Hammersley, 1992). However, there are many areas where ethnography has provided important insights that have enabled later developments. In CSCW, ethnography has received serious attention as a method for informing system design (Crabtree, 2003), as will be discussed further below. Research has been carried out to consider methods for integrating ethnographic research into the design process (e.g. Hughes et al., 1997; Viller and Sommerville, 1998) and to inform changes in management practices. Whether research affects practice is also determined by attitudes in that area and not just the research methodology. In 1977, Millman produced an ethnography looking at medical error in

hospitals in America, yet the Institute of Medicine only published its report on medical error (Kohn et al., 1999) more than 20 years later. But research using quantitative data was also neglected. For example, the Australian Incident Monitoring Study (AIMS) (Webb et al., 1993) was started in 1987. It is true that research from AIMS is more acknowledged in the medical error literature than Millman's work, but this is also a result of the research areas that the work was published in; Millman's work is often quoted in sociological studies of medicine because this is the audience it was aimed at, whereas AIMS research was aimed at the medical community and as such has received more attention from this audience.

It has been argued that ethnographies are too situation-specific to provide information that is useful in other situations. In ethnography, there is the distinction between 'macro' theories, theories that apply to large-scale systems of social relations, and 'micro' theories, that apply to more local forms of social organisation (Hammersley and Atkinson, 1995). It is important to appreciate that many findings will be situation-specific but there will still be findings that have significance outside of the research location. For example, Suchman's (1987) study of photocopier use has had significance far beyond the design of photocopiers, having had a huge influence on our understanding of technology use generally.

Despite the limitations of ethnography, it was felt that, for the purposes of this research, the benefits outweighed the limitations. Ethnography as a method of data collection is described in more detail below.

4.2 Ethnography: some background

Ethnography is a broad approach to the study of people in their environments, an approach that emerged from the field of anthropology in the early 1920s. It aims to produce 'folk' (ethno) 'pictures' (graphy), descriptive portraits of what people do as understood by themselves. The methods of data collection involve the researcher participating directly in the setting, in order to collect data in a systematic manner but without meaning being imposed externally onto the data (Hammersley and Atkinson, 1995; Brewer, 2000). Such periods of fieldwork typically last several years.

Sociologists also have a history of fieldwork, starting in Britain with the late nineteenth century social reform movement and the social survey and systematic observation methods used to document the unseen conditions of London's poor (Van Maanen, 1988). However, it is the Chicago School, dominant within sociology from 1892 to 1942, which is typically considered to be the main force behind sociological fieldwork. Between approximately 1917 and 1942, Robert E. Park and Ernest W. Burgess trained a group of students, who they encouraged to explore the city as if it were remote and exotic, with emphasis on direct participation in these cultures (Deegan, 2001).

There is a strong tradition of sociological ethnographies that consider different aspects of the medical profession and medical work. These include Sudnow's (1967) study of staff reactions to death and dying within a hospital, Strong's study of encounters between doctors and the parents of disabled children (1979), Atkinson's (1981; 1995) studies of medical training and medical talk, and Heath's (1986) study of body movement in medical consultations. There have also been ethnographic studies by Millman (1977) and Bosk (1979) that consider error within medicine.

4.3 Ethnography and the study of technology use

Efforts to incorporate ethnography into the development of technological systems has stemmed from the growing recognition of the fact that the success of design has much to do with the social context within which such systems are to be used (Crabtree et al., 2000). As well as providing a more complete picture of technology use, the practical benefit of ethnographic methods is that they sensitise designers to the real-world character of activities, encouraging designs that resonate with the circumstances of use (Crabtree et al., 2000). It is following on from this awareness of the need to understand work practice that the growing collection of workplace studies, described in Chapter 2, emerged.

The following sections describe in more detail the approach to ethnography used in this thesis.

4.4 The study

Observations were carried out in three Scottish intensive care units. In the units where the observations were carried out, there are between five and eight beds. All of the units were general ICUs, as opposed to being, for example, cardiac ICUs or surgical ICUs. However,

all of the ICUs did treat post-surgical patients and therefore the types of cases that they received were to some extent affected by the surgical speciality of the particular hospital.

The first study lasted eight weeks, and then two weeks were spent in each of the other two units. During the first study, observations were carried out three days per week, 7:45 a.m. to 8 p.m., or 7:45 p.m. to 8 a.m., providing a sense of how the work varies over the day and night. By only carrying out observations three days a week, this allowed adequate time to write up notes in between observations. For the later studies, observations were carried out over the same hours but for five days per week. As these studies were only lasting two weeks each, writing up notes in the evening and weekends was considered adequate. In total, over five hundred hours were spent carrying out observations.

The study could be described as an unobtrusive ethnography. During the fieldwork, ways of working were established that were useful for the purposes of data collection but not too intrusive for the members of staff or the patients. The majority of the time was spent either sitting by particular patients, varying which bed space was observed, or sitting in a position where it was possible to observe the whole of the ward. Training on medical devices with some of the nurses was also attended, and device manuals and hospital equipment policy documents were looked through. Meetings of both nurses and doctors were attended. For most of the time, the units that were observed were full, but very quiet times were also observed, for example, when only two out of five beds were in use.

An understanding of the equipment used in intensive care was gained through explanations that were provided by a consultant at a hospital visited before observations began, and through explanations provided by nursing staff early in the fieldwork. Sitting by a nurse who was explaining equipment to a student nurse or to a new member of staff also provided an opportunity to learn. Because of the complexity of the setting, it was necessary to carry out interviews with nurses to improve the understanding of particular events. However, this was done in an informal way and at times that were convenient for the members of staff, for example, during coffee breaks and quiet moments. Interviews with doctors were carried out in a similar manner. Medical details were also regularly checked with a consultant at another hospital.

Notes were taken on the ward, because it would have been difficult to get enough information down otherwise, particularly technical information and quotes. At the beginning of each day, a note would be made of basic things, such as how many patients there were in the unit, and what equipment each patient was attached to. At certain points, an effort was also made to record monitor alarm settings for each patient. The notes consisted of information about a huge range of events and behaviours that were witnessed, many of which had no direct relation to the technology or its use but which contributed to an understanding and sense of the setting. On the days when fieldwork was not being carried out, these handwritten notes were typed up. (Extracts from both the handwritten and typed notes can be found in the Appendix).

As well as field notes, many ethnographers use video and audio recording as a way to collect data (Heath, 1997). Within the ICU, such methods raise complications regarding patient consent, due to the fact that many patients are not conscious. Therefore, the collected data consisted largely of hand-written notes.

After the period of observation, interviews were carried out with nurses to validate the analysis of the data, both at hospitals where observations were carried out and elsewhere. This is discussed later in this chapter, in Section 4.7.4.

4.5 Analysing ethnographic data

The old style of interpretation was insistent, but respectful; it erected another meaning on top of the literal one. The modern style of interpretation excavates, and as it excavates, destroys; it digs “behind” the text, to find a sub-text which is the true one.

- Sontag, 1994

Ethnography typically produces a large quantity of data in a variety of forms. In the case of this study, the ethnographic record consisted of not only field notes recounting events, the activities of people in the different ICUs, conversations, meetings, gossip, but also sketches of ward layouts, devices, and the arrangement of devices around the bed, and photocopies of documents such as user manuals and hospital policy on the procurement of devices.

The ethnographic record generally appears messy and confusing, if not absurd, to anyone but the fieldworker. The ethnographic record needs to be ordered, and this is achieved through the process of analysis, whereby data is produced and findings are extracted from the ethnographic record (Crabtree et al., 2000). However, ethnography is by no means a unified method (Hammersley and Atkinson, 1995) and the main variation is in relation to the way in which the collected data is analysed and presented.

The development of classification schemes for coding, and thereby ordering, data is an accepted method within both anthropology and sociology, and has a long history in both of these fields (Wolcott, 1999). Several approaches that have been used to study the use of technology are Actor-Network Theory (Law and Hassard, 1999), Activity Theory (Nardi, 1996), and Distributed Cognition (Hutchins, 1995). However, such analysis can be considered as ‘constructive analysis’ (Crabtree et al., 2000). It has been argued that instead of presenting, finding or ‘discovering’ the phenomena, the analysis actually constructs it, by fitting the data within a predefined framework. (Certainly, it could be argued that we always construct the phenomena, in the sense that there are always acts of selection within the analysis of ethnographic data. This issue is returned to in Section 4.5).

It is also argued that such approaches to analysis privilege the analyst’s stance. Such studies may claim that working unnoticed in the background are social forces of some kind that shape what people do, suggesting that people may think they know what they are doing but really they do not, thus producing an ironic account of human activity. For example, they may think they are doing x (filling in a patient record) but really they are doing y (contributing to an actor network) (Crabtree et al, 2000). It is such analysis that Sontag (1994) criticises in the quotation given at the beginning of this section.

Such constructive analyses have been criticised for ignoring the details of how work is actually done. It is argued that such approaches fail to make the ‘taken-for-granted’ available for inspection, since the practice of coding and classifying hides the detail that exists within ethnographic data (Crabtree et al., 2000).

The use of constructive analysis techniques and the associated lack of detail is considered to be a side effect of the need to produce an analysis of work. The details of work are not held to be adequately interesting as they are, well organised accounts of “just what

happens” being criticised for being reportage, not academic analysis. In his ‘mundane manifesto’, Brekhus (2000) laments the fact that for a scholarly article to be considered interesting, it must be deemed either factually interesting (i.e. statistically unusual), morally interesting (i.e. politically important), or analytically interesting (i.e. counterintuitive or theoretically interesting). It is the concern to satisfy the requirements of an explanatory work programme, which always asks ‘why?’, that prevents the production of adequate descriptions of work. It is thought that to be rigorous in describing human activities, one must produce explanatory theories (Wittgenstein, 1968).

What is needed is a method for the analysis of ethnographic data by which we can create such analytic descriptions, while preserving the details of the activities that they profess to describe, not losing the detail and the sense of the setting in the process of coding.

4.5.1 Ethnomethodology

An approach that has been highlighted as a method for the production of ‘perspicuous representations’ (Wittgenstein, 1968) is ethnomethodology (Crabtree et al., 2000). Ethnomethodological approaches to ethnography have been popular in the fields of HCI and CSCW at least since Suchman (1987) used this approach for the basis of her *Plans and Situated Actions*. For ethnomethodologists, the social organisation of domains of work can be understood without recourse to specialised practices of description, relying instead on close inspection and description of events, actions, and objects. Ethnomethodology is concerned with the *haecceities* of activities, by which we mean the qualities of activities that make them what they are. There is emphasis on being able to discuss the setting and its activities in the terms of those in the setting, rather than restricting our descriptions by relying on the language of a particular theory (Garfinkel, 1996).

Ethnomethodologists reject the practice of coding and classifying data through the application of predefined taxonomies and analytic frameworks such as those mentioned above. The aim is not to produce theory. Emphasis is placed heavily on ‘explication’, on detailed description, as opposed to ‘explanation’ and the building of theories (Crabtree et al., 2000), thus moving away from those ‘why’ questions criticised by Wittgenstein.

Most approaches miss the mundane details of a setting, of interaction, because we cannot see that which is too familiar to us (Wittgenstein, 1968). With an ethnomethodological

approach, an attempt is made to suspend the moral stance on the activities observed and instead concentrate on recovering the situated rationality of the events observed (Payne et al., 1981). For example, the study presented in this thesis should not concern itself with whether or not it is morally right for nurses to customise devices but should focus on detailing the nurses' own perspective on the process of customisation. Ethnomethodologists look to see what people are doing, rather than look to identify things that are sociologically interesting. The trivial features of a setting thus become notable features, no longer just “noise” to be eliminated (Crabtree et al., 2000).

Ethnomethodologically-informed ethnography has been promoted within HCI and CSCW as a means for informing system design (e.g. Luff et al., 2000). Researchers at Lancaster University recommend a process of “quick and dirty” ethnography, lasting anything between a couple of days to three weeks (e.g. Hughes et al., 1994; Crabtree et al., 2000). This is followed by the assembling of instances of discrete activities from the ethnographic record, instances that preserve and display the lived work of witnessed activities. These instances are then described and explicated in detail.

4.5.2 Limitations of ethnomethodology

Again, it is necessary to consider the weaknesses of this approach. Because ethnomethodology is not concerned with producing theory, instead being concerned with detailing everyday activity, it has been argued that ethnomethodology is just an expensive means of telling us the obvious (Shapiro, 1994). What it tells us is obvious in that it reveals nothing ‘new’, everything that it tells us is already before us. However, it is not the point of ethnomethodology to bring revelations. Ethnomethodology's benefit is its ability to sensitise us to those things that are so part of our lives that we can no longer see them.

As with ethnography generally, ethnomethodological analyses have also been accused of being subjectivist and relativistic. Ethnomethodologists adopt a pragmatic approach to the issue through devices such as ‘ethnomethodological indifference’ and ‘bracketing’. This allows one to get away from asking whether things really are the way those in the setting say they are, by instead examining what those in the setting say they are and how they satisfy themselves that things are that way. In this way, ethnomethodology avoids asking the unanswerable questions of why people say things or why people do things; answers to such questions can never be more than purely speculative. For example, if a nurse tells the

fieldworker that they bought a device based on a laptop demonstration, this could be that this is the case, or she could be saying it for effect, or she could be saying it because that is the story she has been told. The possibilities are endless. An attitude of neutrality is adopted, and similarly the policy of indifference is not a relativistic policy at all but one which refuses to judge the truth claims of competing accounts.

However, objectivity is often used to say that someone is concerned to ensure that the phenomenon is adequately and correctly described, in the sense that it is not dominated by the preferences and prejudices of the inquirer. Ethnomethodology has been criticised on the basis that, without a formal model, the data is too dependent on personal interpretation. It has also been criticised for not adequately considering the role of the researcher in the setting (Denzin, 1969). However, ethnomethodology is focused on visible orderliness, so that most ethnomethodologists would claim that their observations are ‘grossly observable’, available to just about anyone, tying in with the fact that the aim of ethnomethodology is about explication as opposed to explanation. In this sense, ethnomethodology can be said to be objective, in the sense that it gives primacy to the phenomenon and insists that inquiries be directed towards revealing its properties. In contrast, what are often considered as more objective methods often force the data into formats that cannot satisfactorily contain such data within them. This seems to involve obscuring or distorting the properties of the things being studied and that is hardly consonant with the meaning of objectivity. However, Shapiro (1994) claims that ethnomethodology’s program is equivalent to instructing the researcher to describe those and only those aspects of the setting that can be used to demonstrate its self-ordering properties, and to organise the descriptions such that it emphasises those properties, so that not only does it specify where to look but also what to find. Such a criticism seems equivalent to criticising a geologist for just wanting to look at rocks; the geologist is not saying that there is nothing but rocks, just that rocks are what she is interested in. Again, here it is important to draw a distinction between Garfinkelian “pure” ethnomethodology and ethnomethodology in practice. Some examples of ethnomethodological analyses do appear to simply try to organise their data to demonstrate Garfinkel’s original findings. However, this does not deny the usefulness of other studies. What is important is that ethnomethodological studies of work take as their only topic how members accomplish their tasks. This implies no commitments of any kind as to the merits or otherwise of members’ world views, attitudes, assumptions and so on.

Another common definition for objectivity is the requirement of reproducible results. Sharrock and Anderson (1986) claim that ethnomethodology has “made sterling efforts at it.” Ethnomethodologists have sought to make their data available for the direct inspection of others, and to make as explicit as possible the steps by which they have investigated it, in order that colleagues may see how conclusions were derived from the material and may replicate the analysis for themselves. Again, Shapiro (1994) comes in to question the interpretive character of what are supposedly “first order” observations. In this, he looks at specific examples of work from Conversation Analysis (CA) and claims, convincingly, that the explanation is not provided in the data. Again, it is important to distinguish between Garfinkelian “pure” ethnomethodology and ethnomethodology in practice. Also, it is not fair to criticise a method due to its poor application.

4.6 An ethnomethodologically-informed analysis

This study will aim to be an ethnomethodologically-informed ethnography of the kind described above. Thus, it follows in the tradition of variety of researchers working in the fields of HCI and CSCW who are using such methods (e.g. Bentley et al., 1992b; Button and Harper, 1993; Harper and Hughes, 1993; Suchman, 1993; Heath et al., 1999; Hartswood et al., 2003a). The commitment will be maintained to the phenomena at hand, with the inclusion of field notes and quotes in order to provide an impression of the work and the setting to the reader.

Although by no means a traditional ethnography in terms of timescale, this was not a ‘quick and dirty’ ethnography. Some process of coding was therefore necessary, due to the large quantity of data. A process of coding enabled identification of aspects of the data to focus on. Also, because the purpose of the research was not for the design of a particular system, the assembling of discrete activities as proposed by Crabtree et al. (2000) did not seem appropriate.

In carrying out the analysis of the ethnographic data for this research, all of the collected data was read through several times, before beginning the process of what could be termed ‘loose, bottom-up coding’. This was not the coding of data through the application of a predefined taxonomy. Instead, the data was coded to highlight instances relating to what appeared to be recurrent themes, adding new codes as necessary. While this is in some

ways similar to the Grounded Theory approach (Glaser and Strauss, 1967), with Grounded Theory the data already examined is not re-examined on the identification of new categories. In contrast, for the analysis presented in this thesis, as new categories were identified, the data already examined was re-examined.

Having decided to look at a particular topic, all the instances relating to that topic would be brought together. For each instance, a detailed analysis would be carried out, drawing out the detail of what was happening. These instances would then be compared, so as to see what aspects were present throughout the instances and in which ways the instances differed. For example, in looking at the topic of the adjustment of alarm settings by nurses (presented in Chapter 7), all instances were looked at in order to compare aspects such as who carried out the adjustment, the alarm setting selected and the level of experience of the nurse carrying out the adjustment. Such a method of coding and the comparison of instances can be compared to the constant comparative approach used in Grounded Theory (Glaser and Strauss, 1967), although a greater commitment was made to the preservation of detail than is typical of Grounded Theory analyses.

The choice to use an ethnomethodologically-informed approach to analysis naturally has significance for the selection of topics on which this thesis focuses. There are always many acts of selection within the analysis of ethnographic data, an inevitable accompaniment to the crafting of representations relevant to particular purposes (Suchman, 1995). Ethnomethodology's concern with the detail of what people actually do means that the analysis presented here will not deal with sociology's 'grand themes' such as gender and power. This is not to deny the importance of such themes in the use of medical technology. Gender, for one, has been shown to be of significance in the appropriation of medical technologies (e.g. Novek, 2002). Rather, the decision to avoid such themes is based on an awareness that the discussion of such themes tends to be at the cost of a loss of detail (Brekhus, 2000; Crabtree, 2003).

4.7 Validation of analysis

Ethnographers are more and more like the Cree hunter who (the story goes) came to Montreal to testify in court concerning the fate of his hunting lands in the new James Bay hydroelectric scheme. He would describe his way of life. But when administered the oath he hesitated: “I’m not sure I can tell the truth... I can only tell what I know.”
- Clifford, 1986

With ethnography properly done, ethnographic description has such a sense of verisimilitude, such a sense that “this must be the way things happen,” that the descriptive materials provide a prima facie case for the validity of theoretic argument...
- Bosk, 1979

Ethnography and ethnomethodology have both been criticised for being too dependent on personal interpretation, ethnography because of the flexibility of the method and ethnomethodology because of its absence of a formal model (Sharrock and Anderson, 1986; Shapiro, 1994). One of the major challenges of carrying out research that uses methods from the fields of anthropology and sociology within the field of computer science is reconciling the two very different research traditions, and different attitudes towards concerns such as validation, that exist within those fields.

While readers who have read a particularly convincing ethnographic study might agree, or at least understand, the sentiment expressed in the quote from Bosk given above, the cautious computing science PhD student cannot rely on her writing talents alone to demonstrate the validity of her analysis. However, despite the large quantity of literature within the fields of HCI and CSCW about how to go about the process of carrying out an ethnographic study, there is little discussion about how to validate the results. Suchman (1995) argues that the representations of work produced by ethnography should be treated as part of the fabric of meanings within and out of which all working practices are made, not as proxies for some independently existing organisational processes. Roth and Patterson (in press) argue that we need different means of assessing observational research, that what matters is not whether different researchers would have produced the same analysis. What is important is how ‘generative’ the work is, in terms of how insightful and productive the results are in pointing to sources of performance problems and opportunities for improvement. In a similar vane, Crabtree et al. (2000) argue that ‘the trustworthiness

and generalisation of findings relies on their relevance to systems design insofar as findings make observable the work that design must support if effective technology is to be developed.’ Those taking an ethnomethodological approach to analysis make the argument that their results are ‘grossly observable’, thereby limiting the need for validation.

Even outside of the fields of HCI and CSCW, qualitative researchers have no agreed-upon methods for validating findings. Miles and Huberman (1994) suggest that we cannot validate our findings in any strong sense of the word. Rather, our aim should be to increase our readers’ confidence in the accuracy of what we report. In order to do this, it is considered necessary to demonstrate three facts: that the findings are ‘typical’, that the findings are ‘generalisable’, and that others, typically those in the setting, recognise the analysis as being correct.

Validation is not something to be considered as an afterthought, to be carried out following data collection and analysis. Rather, it should be considered throughout the research process (Miles and Huberman, 1994). For demonstrating the typicality, generalisability, and validity of the analysis, different approaches, at different phases in the research, are required. The approaches that were used for such validation in this research are described below.

It should also be pointed out that, in carrying out the analysis, the data and the analysis of the data was frequently discussed with colleagues, and others were invited to analyse the data in a workshop session. In presenting the analysis, an attempt has been made to include large sections of field notes. While such field notes do not constitute ‘evidence’ in any strict sense, they provide a level of ‘authenticity’ by allowing the reader to decide for themselves if they agree with the analysis of those field notes (Atkinson, 1990).

4.7.1 Typicality

Validation to establish whether what is described is ‘typical’ concerns whether or not what was observed can be considered to be a ‘standard’ occurrence as opposed to being a ‘one-off’ event. Thus, it is a concern during both the data collection and the analysis.

Crabtree et al. (2000) argue that the findings of ethnomethodologically-informed ethnographies are generalisable on the basis that the methods used within a particular

setting are neither restricted to the members observed or the particular location, in the same way that the methods used in “doing-driving-down-the-freeway” are not restricted to the driver observed nor the particular freeway. However, what this misses is the way in which local methods develop within particular locations. An attempt has been made to demonstrate that the findings presented in this thesis are not just a ‘one-off’ by carrying out observations over a period of several months, thus allowing time to gain a sense of what are and what are not regular occurrences.

But how many occurrences of an event need to be witnessed before that event can be classed as typical? The central chapters of this thesis refer to previous studies of medical work, and some of the behaviours they report were not observed during this research. Does this mean that those findings are not valid? Certainly, there are events that we experience in our lives that may only happen every few years or maybe just once in a lifetime (the death of a relative, the birth of a child) but that does not mean that such events are not typical. Rather, they are to be expected. Thus, it does not seem appropriate to set guidelines that state that three or seven or thirty or one hundred observations of an occurrence make a fact or establish a pattern.

A sense of the typicality of an event can be gained by discussing the event or behaviour with those in the setting, an approach to validation that is discussed below in Section 4.7.4. Chapter 5 discusses the introduction of a haemofiltration device into one of the ICUs. As it was not possible during the fieldwork time available to observe the introduction of more than one device, the introduction of the haemofiltration device was discussed with nurses in the setting to get a sense of whether that particular introduction was similar to their experiences of the introduction of other devices in the unit, and was also discussed with nurses at the other units where observations were carried out, to see how it compared to their experiences.

4.7.2 Generalisability

Validation to establish whether what is described is generalisable concerns whether or not what is related in this thesis can be generalised to be true of other ICUs, other areas of medicine, other areas of technology. It cannot be proved that the findings are true for all types of ICUs, or that they are true for all ICUs in the UK, or even that they are true for all Scottish ICUs. However, an attempt at this form of validation was made by carrying out

observations in three different units in three different hospitals, and across two different hospital trusts and two different cities. Reports on the research were also given to nurses in ICUs where observations were not carried out, so that those nurses could comment on whether the reports fitted with their experiences. (This approach is discussed further in Section 4.6.4 on respondent validation). Thus, what is known is that the findings of this thesis are not unique to or linked to a particular unit, hospital or trust. The topic of generalisability will be returned to in the final chapter of this thesis, when the methodology used in the thesis is reflected on.

4.7.3 Accuracy

The methods of validation necessary to establish whether the analysis can be considered 'correct' are dependent on the setting. Certainly, for a study of intensive care by a student who has no medical background, a fair question would relate to whether or not what was going on in the setting was properly understood. However, throughout the observations, if something occurred that was not completely clear, it would be checked either at the time of the observations, with a consultant or nurse, or during the analysis and writing up of the data, with a consultant at another hospital.

Questions about the validity of the analysis are steeped in the debates about notions of objective and subjective, and the role of 'interpretation' and 'representation' in research, that were discussed above. There are many books on ethnography from the field of anthropology that debate the extent to which ethnography can hope to represent an independent reality (e.g. Clifford and Marcus, 1986; Hammersley, 1992; Van Maanen, 1995; Denzin, 1997). The problem of demonstrating validity is heightened when the reader is presented with just short extracts of data, abstracted from the context in which they occurred, an inevitable consequence of large quantities of data and limited space. However, a practical method for validation is to demonstrate that the analysis is recognised as true by those in the setting. This is done through the process of respondent validation, described below.

4.7.4 Respondent validation

Respondent validation is carried out by providing a report that results from the analysis and allowing those in the setting to give their comments on it. The value of such a technique lies in the fact that those who were observed may have access to additional knowledge of

the context that is not available to the ethnographer (e.g. other relevant events, others' ulterior motives, temporal framework). As Hammersley and Atkinson (1995) describe it, 'They may be part of information networks that are more powerful than those accessible to the ethnographer.' Even if those in the setting do not see aspects of the analysis as true, this provides an important opportunity for further discussion and further developing an understanding of the setting.

For each of the chapters in the central part of this thesis, a brief report was produced, summarising the findings of the chapter. The report for Chapter 5 focussed on data from the unit where the longer study was carried out, so that report was read by six nurses from that particular unit. The reports for Chapters 6 and 7 were read by six nurses from a unit where observations were not carried out. The reports were then discussed with the nurses on a one-to-one basis several days later. While it may have been preferable to discuss the report as a group, to encourage discussion amongst the nurses, it was not possible to get enough nurses away from the ward at the same time. Instead, feedback came in the form of brief, informal discussions at the bedside.

4.8 Summary

This chapter has discussed several methods that could be used for learning about the use of intensive care equipment. It has introduced ethnography as a method for understanding work settings and technology use, and has provided a brief summary of the role that ethnography has played in understanding technology use. The ethnographic approach that this thesis uses was described, along with the ethnomethodological approach used to analyse the data. The limitations of ethnography and ethnomethodology were discussed. Finally, how the analysis that is presented in the following chapters was validated was described.

Part 2 – Appropriation and customisation in the ICU

Chapter 5 – Responding to problems with a new device

Chapter 2 defined appropriation as the process by which people fit technologies into their daily lives and their working practices. An important part of the appropriation of new technologies is discovering and finding ways to overcome and work around the problems and limitations of the technology (Rogers, 1994). This chapter considers a device that was introduced into the unit where the eight week study was carried out. There were various problems with this new device, both in terms of equipment malfunctions and more general usability problems, yet the nurses persisted with the device. The chapter explores how the nurses appropriated the new device and how they attempted to overcome such problems. This allows for discussion of some typical problems that nurses experience in their interaction with medical devices. Aspects of their relationship with the devices' manufacturers and distributors are described.

The device that this chapter focuses on is a haemofiltration device. It was previously the case that haemofiltration in this ICU was carried out by the renal department. Thus, if a patient in the unit required haemofiltration, a member of the renal department would come to the unit and set up the treatment. In early 2001, the renal department was moved to another hospital within the trust. This meant that ICU staff had to purchase a haemofiltration device and learn to provide haemofiltration.

Initially, the unit purchased what they described as a 'basic' machine. They then tried a few 'more advanced machines' and chose one particular model. The unit purchased two haemofiltration devices of this model approximately five months before observations began. Although the device can provide six different treatments, including ultrafiltration, haemodialysis and therapeutic plasma exchange, they only use the device for Continuous Veno-Venous Haemofiltration (CVVH). A conventional dialysis treatment lasts for approximately four intensive hours, thus creating enormous changes in the patient's body over a relatively short space of time. In contrast, CVVH is considered to be a gentler treatment, because it can run for twenty-four hours a day.

The purchase of the haemofiltration device was unique within the unit from the perspective that it was a nurse-led purchase, most purchases within the unit being led by the consultants, with nurse input. Thus, the purchase was led by the future users of the device.

Specifically, the purchase was led by the renal core group, a group of nine nurses responsible for researching advances in renal care. They then also became responsible for training other nurses to use the device and with contacting the distributor or manufacturer when there were problems. In the initial uses of the device, it was also members of the renal core group who set-up and operated the device, because they were the nurses who had received training and had some experience in using the device. Thus, we see that the renal core group nurses have several recognised accountabilities relating to the haemofiltration device: to purchase the device, to train others, to liaise with the manufacturer and distributor, and to set-up and operate the device. The nurses' local accountabilities will also be explored in this chapter.

Haemofiltration is a complex treatment and, before going on to describe some instances of the use of the haemofiltration device, it is necessary to describe some of the basic concepts and some of the most common problems. Haemofiltration is performed on patients whose kidneys have ceased to function. It is a form of dialysis, a technique of removing waste materials and poisons from the blood. Before beginning treatment, any air must be removed from the circuit, and this is achieved when priming the device with saline solution. The device must also be programmed. This involves setting a series of parameters, for example, to define the speed at which blood will be taken from the patient, referred to as the 'blood flow'.

Once the device has been programmed and primed, haemofiltration can begin. The stream of blood is taken from an artery through the dialysis line, and is circulated through the haemofiltration device on one side of a semi-permeable membrane. Water and waste products from the patient's blood filter through the membrane, whose pores are too small to allow the passage of blood cells and proteins. Fluids and electrolytes (such as sodium and potassium) are replaced and the purified blood is then returned to the patient's body through a vein.

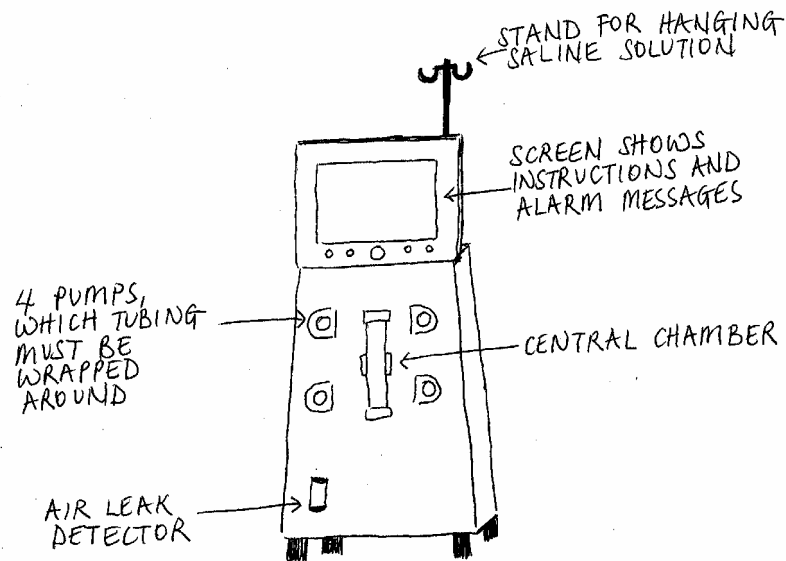


Figure 4.1: A drawing of the haemofiltration device

ICU staff will often talk about ‘access to the patient’. By this, they are referring to the catheter, a flexible tube that is inserted by the SHO into the vein. For haemofiltration, two catheters are required, one for removing blood and one for returning blood to the patient. These tubes are then attached to the main tubing of the haemofiltration device. As is discussed below, problems with the insertion of these catheters can cause problems for the provision of haemofiltration.

The haemofiltration device continually monitors pressures on the ‘arterial’ (i.e., from the patient) and ‘venous’ (i.e., return) sides of the circuit and alarms automatically when pressures are outside acceptable ranges. When pressure on the arterial side is too low, this suggests that blood flow from the patient is inadequate. This is usually due to a problem with the access to the patient. It could be that the catheter is not adequately inserted or the patient is lying in a position that is obstructing the passageway of the tubing. If pressure in the venous side is too high, blood return to the patient is inadequate. This is again usually due to a problem with the access to the patient or a clot in what we will refer to as the central chamber, where the blood is actually filtered. If venous pressure is too low when arterial pressure is adequate, there may be a leak or disconnection in the circuit, or the pump speed is too slow for the size of the catheter. What these alarms are essentially ensuring is that the patient is not losing too much blood or being returned fluid too quickly.

Below, a series of short descriptions are presented, describing a selection of the events surrounding the haemofiltration device as they were sequentially organised. Through this, we will follow the nurses' persistence. This is intended to give the reader a sense of the types of problems the nurses encountered and how they responded, as well as a sense of how the response to the device was continually changing.

As is the case throughout the thesis, names of members of staff, of hospitals, and of places have been changed.

Vignette 5.1

The first experience of actually seeing the device being used was a couple of days after observations began. At the beginning of the shift, Caroline set up the haemofiltration device using the operating manual. She said that she was “just practising”. Caroline had difficulty attaching the necessary sets of tubing. She also had difficulty to select the right option from the menu first time, because the cursor moved too quickly over the options. When the device started to prime, Caroline said, “Well, I must have done something right because it's working now.” Caroline told the fieldworker, “When [the device] is running, it's fine,” that the difficulty is in setting up the device. Eventually, the device was primed and attached to the patient, and treatment was started. Ben, the charge nurse, came over and Caroline cautiously told him she had “primed it of a fashion.” She said she would write down how she had done it so that she would have it in her own words, because she felt that the user manual was not easy to follow. Caroline told Ben that when priming the haemofiltration device with saline solution, the device normally primes all four pumps, but this time it missed one out and she did not know why.

That afternoon, when the haemofiltration device was running, there was a venous pressure alarm. In response, Caroline tried different blood flow levels, moving between the manual and the machine. The device stopped alarming and the venous pressure appeared to be adequate.

Similar messages appeared later in the afternoon. Later on, the device alarmed again. This time there was no message but the screen showed that there was high venous pressure. On around the tenth alarm, a message appeared. Ben came over and said that it looked like the patient's blood was clotted in the central chamber. Later, the message appeared again and the device continued to alarm, despite Caroline's attempts to stop the alarm. Caroline grew increasingly frustrated, saying, "Oh, for goodness sake" and looking at the machine, shaking her head.

Approximately ten times, the machine displayed a message stating that the venous pressure was low. An alarm message stating that the venous pressure was high followed this. This was at variable intervals of around 10 seconds. Sometimes the alarm sounded but there was no message. This was followed by a series of messages, as the device stopped the blood pump and the balance system.

Caroline restarted the machine. Again, an alarm message came up, stating that the venous pressure was high. Caroline stopped the dialysis and then started it again. This time there was a message stating that the arterial pressure was high. Caroline sighed, saying to the machine, "Oh, would you just go". She gave up, saying loudly, to no one in particular, "I think we've lost it." Rachel, another nurse, came over and asked Caroline, "Is it gubbed [broken]?" Caroline said she was "just trying to give [the patient] her blood back." Caroline closed the machine down. Rachel said to the consultant, "It's an evil machine, Mark. We said that a few months ago."

An hour later, Caroline decided to try again and started setting up the haemofiltration device for a second time. There was no apparent difference in how she set up the device compared to how she had set it up before. This time, there were no error messages. Caroline explained to Ben how she had set it up. She was visibly pleased, smiling broadly. Caroline said to Becky, the supernumerary nurse working with her, "I feel a lot happier now, more confident...I feel quite chuffed now." Ben said to the fieldworker, "It looks quite impressive, doesn't it?" When Caroline explained the previous

behaviour of the device, she said that it occurred due to “some reason” and “because [the device] wasn’t happy”. Ben was also questioning of the behaviour of the device. Looking at the machine, Ben said to Caroline, “It’s not really doing much, is it?” Caroline replied, “It takes a wee while.” Shortly after, Ben came over again and asked Caroline, “And it’s working fine now?” Caroline replied, “At the moment.”

When Lisa arrived to take over from Caroline and Becky for the night shift, Lisa asked Caroline, referring to how Caroline got the haemofiltration device working, “What did you do?” Caroline replied, “I don’t know, I just took it all apart.”

Vignette 5.2

When observations continued just over a week later, the same patient was again attached to the haemofiltration device and being looked after by Caroline.

The second haemofiltration device of the same model was also on the ward because it was believed by the nurses that the behaviour of the device was “not normal”. The device had been attached to the patient but they swapped it because of unexplainable error messages that were appearing. Caroline started this second device again to see what would happen. Sarah said that it was “just stuck”. They thought that it might have been due to a problem with how it was set up, Sarah saying, “It’s funny that it was okay before and it primed when you and I did it.” Therefore, Caroline decided to “take it apart” (i.e. remove the disposable tubing) and “put it back together” (i.e. put on a new set of disposable tubing, and program and prime the device).

When they started the device again, messages appeared which Sarah interpreted as meaning that the problem was with the device, saying that she “read in the manual that if it says CPU you should report it”. Therefore, Caroline telephoned the help line and spent approximately ten minutes explaining what had happened. The person on the help line told her that she was ‘not doing it right’. Caroline came back and said, “We thought it was

an internal problem but it's not." They went back to treating the problem as due to how the device was set-up. Caroline said that in the renal core group meeting they would "iron out these problems" and produce a step-by-step "idiots' guide".

Vignette 5.3

The following week, the October renal core group meeting was held. This was a monthly meeting where members of the renal core group got together to discuss any developments in renal care and any relevant experiences and issues. Eight of the nine members were present. The main topic of conversation was the haemofiltration device. The meeting started off with the nurses acknowledging that they had had some "positive" and some "negative" experiences with the haemofiltration device. On a practical level, actions were planned, such as the development by several of the group's members of a new user manual, and training of other members of the ICU. It was also decided that they would keep a diary of problems and how they overcame them (the book that this was to be recorded in was later named as "the New Testament", in relation to the nurses' communication book, which was known as "the Bible"). They also discussed whether or not to get the distributor to provide another training session.

Sarah emphasised the learning of other functions as an opportunity to "extend [the nurses'] roles". Sarah also identified it as the group's job to encourage a positive attitude towards the device among the other nurses. The group acknowledged that there were some people who had very negative attitudes towards the device. However, the reason for such 'fear' was ascribed to the fact that the device was the "most hi-tech" equipment they had in the unit.

Sarah said that they took a risk with the device in that it was new but it was worth it because it was the best on the market. The problems were treated as temporary problems, Sarah saying that she hoped they were just "teething problems". She said that if they were not temporary problems,

they would “have to work with those problems”, suggesting that even if not temporary, the problems were manageable.

It was suggested by one of the nurses that they were “effectively testing the device”. Ben said that they should have got nurses in to try it before putting it on the market. Lucy said that one of the representatives from the distributor “washes her hands” of problems by telling them to telephone the help line. The nurses had asked questions, to which the representatives had not given them answers. There was an acceptance that the representatives were not going to be of much assistance, and it was felt that the representatives were also learning the equipment. It was also mentioned that the help line had given them contradictory information about the CPU error messages.

Vignette 5.4

A week and a half later, the same patient was on the haemofiltration device over night, but the device kept alarming. When James handed over to Julia, he said that the dialysis line (through which the device is attached to the patient) was “gubbed.” However, they could not be certain that this was the reason for the problems, so they called for an engineer. They were told that an engineer could not come that day but would come the following day.

The consultant and the SHO said that the nurses should try the haemofiltration device again. This would mean using a new kit containing the disposable tubing needed for the device. Julia was anxious about doing this because they only had two kits left. They had used many kits the previous weekend because problems meant that they kept setting up the haemofiltration device and then taking it apart again, each time having to use a new kit.

Julia showed Fiona how to set the haemofiltration device up. Julia told Fiona that “you feel good when you [set it up]”, that the device “tells you step-by-step [what to do]”. Echoing Sarah’s opinion that the problems were problems that could be overcome, Julia said that “the more problems [they]

get, the better [they are] getting at it.” Fiona turned on the device and the system test began. An alarm message came up, about CPU1 and CPU2, but a different message to the message that had appeared before, referring to the blood pump and the heater. Fiona cleared these messages and they then added the lines. Julia asked Fiona and the fieldworker if they saw all four pumps turning on the self-test. Once the device was attached to the patient, messages came up about CPU1 and CPU2, which Julia cleared.

Fiona said to Julia, “Tell me what I have to do before I do it.” Julia reassured Fiona that the screen would tell her “step by step” what to do. However, Fiona found the device unclear, saying “[The screen is] not really telling you anything [about what is happening].”

Before beginning treatment, any air must be removed from the circuit, and this is achieved when priming the device with saline. However, air appeared to be trapped in the tubing. Fiona said, “I wonder why that air’s not getting pushed out.” Julia replied “I think [the central chamber] is up too high”. Julia said, “I’ve turned the blood flow up to see if it gets it going.” An alarm message appeared on the screen, saying ‘high venous pressure, blood pump off’. Julia said, “I don’t know if it’s because we swapped the lines round...It’s stupid, it’s not letting me do anything.” Fiona suggested telephoning the help line but Julia said she thought it was due to a problem with ‘the line’. Fiona adjusted the dialysis line and the blood pump started. The machine was alarming. Julia asked Fiona, “What’s it saying?” Fiona replied, “I don’t know, it’s stopped saying it.” The message appeared again and Fiona read it to Julia. They stopped the device.

Julia complained that the task had been time-consuming, saying that it took two nurses an hour and ten minutes to set up something that ‘did not work’. Fiona said, “I don’t think I like the design of this machine.” Julia and Fiona both considered the problems to be due to the access to the patient, which is what Julia had initially told the consultant and SHO, as access to the patient was their responsibility. Julia said that a representative from the distributor was coming in later. Fiona said that would be too late. Julia said, “Did I not

talk you through that fine?” Fiona replied, “Yeah, but the doctors would’ve listened to him.” Fiona felt that, with the backing of the distributor, the consultant and the SHO may have agreed to reinsert the line.

Vignette 5.5

At the December renal core group meeting, discussion again focused on the haemofiltration device. The two haemofiltration devices belonging to the unit were not being used. This is because the CPU error messages that had been appearing were considered by the manufacturer to be due to a problem with the device. The distributor had loaned the unit another machine of the same model. Sarah talked about a patient who had been attached to the loaned haemofiltration device for over thirty hours, saying, “That must be a record. I think that’s worth minuting.” Sarah said that, according to a representative from the distributor, “down South” they were no longer having problems once they had the new software. She emphasised the fact that “people are taking an interest”, with the pharmacists wanting a tutorial on CVVH (the particular form of treatment they were providing) and the other nurses in the unit “very keen to get up to speed.” Sarah gave out details of a ‘Haemofiltration in Practice’ workshop, which half the group would go to, reinforcing the idea that the new device is an opportunity for the group to learn. She said, “Haemofiltration is a nurse-led practice in this unit, I like to think.”

5.1 Ambiguity

It is presumably not clear to the reader from the vignettes exactly what was causing the problems that were experienced with the haemofiltration device and, at the time, this was not clear to the nurses themselves. The device presented alarm messages, both during the setting up of the device and whilst providing treatment. There were problems regarding the venous pressure and arterial pressure, but the CPU error messages related to a problem with the device. These messages were not in the user manual, although it is possible that they were in an earlier manual because, as we see in Vignette 5.2, Sarah had previously read that any message referring to CPU meant that there was a problem with the device. Although, in Vignette 5.2, the nurse is informed by helpline personnel that the message did not mean there was a problem with the device but rather that there was a problem with how

the device had been set up, a later call to the helpline confirmed that the message did mean there was a problem with the device. After this, an engineer came from the manufacturing firm.

However, error messages continued to appear and the problems persisted, until a loaned device was used. Both machines belonging to the unit were put out of use until a software upgrade could be provided. This software upgrade was promoted as providing new features but also, importantly, the problems that had been present in the previous software were removed.

Although in Vignette 5.2, Sarah believes that the CPU messages mean that there is a fault with the device, the vignettes show that previous to that and following on from that, nurses persisted with the equipment despite these messages. Difficulties in providing haemofiltration can be caused by one (or more) of several main problems. It may be due to how the device was set-up (e.g. the tubing incorrectly attached, or air in the tubing), a problem with the access to the patient ('the line'), some aspect of the patient's state, such as the coagulation level or venous pressure, or a fault with the device itself.

It is important to note that the attachment of any technology to a patient is always surrounded by potential hazards (Strauss et al., 1985). The hazards of machines and their associated therapy and drugs are maximised when attached to a patient, especially when linked with the use of multiple machines and multiple therapies. The interaction of these elements must be monitored, and the interaction of these elements can be difficult to comprehend. As was described earlier on in the chapter, venous pressure and arterial pressure alarms can be caused by a variety of problems. In other settings, users may be able to draw on 'information' such as the sound a device makes, watching the movement of the physical parts inside the device, or looking at error logs (as in (Orr, 1996)) to determine whether or not there is a problem and what is the cause of that problem. The nurses can rely on such methods only for certain problems. For example, if there is high venous pressure, the nurses may inspect the central chamber to see if the blood is clotted. However, other information is not available to the nurses. It was not clear to the nurses from the error messages what the cause of the problems was or what the appropriate action to be taken was. This was in contrast to reassurances from the distributor that the message "should tell you exactly what [the problem] is".

The nurses were also given little information from the distributor and manufacturer that could help them to determine the cause of the problems. When the representative from the distributor came in at the end of October, he said that the problem of the CPU error messages was new and they did not know the cause, whether it was “software” or “hardware”. On another occasion, the nurse was unable to explain to the distributor what had happened. The representative said that she had “no idea what was happening” so she was unable to give any suggestions, just saying, “Well, see what happens.” It was generally the case that the level of information that nurses had varied and, on occasion, it became apparent that nurses had been given contradictory information.

5.2 Routine troubles

In considering the nurses’ response to the haemofiltration device and the associated problems, it is necessary to consider aspects of their experience of medical technologies, and their experience of manufacturers and distributors of those devices, generally. ‘Routine troubles’, or ‘normal, natural troubles’, is a topic that has received attention in previous workplace studies (e.g. Harper and Hughes, 1993; Pettersson et al., 2002; Clarke et al., in press). By routine troubles, we mean those aspects of work that are problematic but are so on a regular basis and are expected to be so. As a result, those in the setting treat the troubles as a natural part of the setting and see it as part of their role to deal with such troubles.

Although it could be argued that, by persisting with the device, the nurses were acting outside of the defined standards of accountability, they were dealing with the haemofiltration device in a way that could be considered the normal, standard way of dealing with technology. Despite reassurances from the distributor that “any of these little things that are causing problems, [the manufacturer will] want to look at it”, the lack of answers meant that the nurses felt very much on their own in their dealings with the device. By the time of the renal core group meeting described in Vignette 5.3, there was a sense of having to manage, to make do, Sarah saying that if the problems they were experiencing proved not to be temporary problems, they would just “have to work with those problems”. There was an acceptance that the representatives were not going to be of much assistance, Lucy saying that one of the representatives from the distributor, “washes her hands” of problems. The nurses did not know where to get answers to their questions,

having received contradictory information from the help line and not getting answers from the distributor.

This feeling of being alone in dealing with the technology was reported in other units and in relation to other devices as well. At another unit where fieldwork was carried out, the ward manager told of his experience of contacting the manufacturer of a syringe driver after an error message appeared that was not in the manual. On initially contacting the manufacturer, he was told that no one else had reported that problem. He then had to wait two months before the manufacturer gave him a response as to the cause of the error message. Shortly afterwards, the device was taken out of use by the manufacturer.

Through experience, nurses become used to dealing with what we could refer to as problematic equipment, meaning equipment which may behave in unpredictable or confusing ways, which may present confusing error messages or may alarm for no apparent reason. This is not to say that there are problems with all or even most of the technologies they use. However, such behaviour is common enough for nurses not to be surprised by it. There is a level of distrust of technology. When one nurse was telling the fieldworker about the hourly data that they note, he said, “You can get computers to print it all out for you. I think it’s good and bad, because you don’t want to over rely on it.” The nurses expect of themselves and each other to not ‘over rely’ on equipment.

This acceptance of problematic technology has been reported in other studies from the medical domain. For example, in her study of the use of interpretative ECG machines, Hartland (1993) described how practitioners were accustomed to machine failures and misinterpretations. As described in Chapter 2, the result of this is that practitioners attend to the possibility of mistakes and adapt their working practices to accommodate the limitations of the machines. Hartland reasons that users ‘acknowledge that part of their role when using the machines is to ensure that such mistakes are recognised’ (p.75).

There is also a tendency to laugh about and discuss what is considered to be the inadequacy of much of the technology. While much of this can be considered as just workplace banter, complaints about conditions being common conversation in most places of work, there is an awareness of how the technology in the unit compares to the technology they have at other hospitals, as well as attitudes about what can be considered

as good technologies. The lab results computer was a regular receiver of abuse from consultants, SHOs, and nurses alike, being described as a “crap”, “hellish”, “time wasting ornament” with a “rubbish interface”. When a digital X-ray arrived from another hospital, someone commented on it and the SHO responded, “It’s from hospital X, where they have proper technology.” One nurse said that she liked the monitors they had in the unit because of the touch screens. Talking about her experiences of technology in other units, she said, “Have you been to hospital Z in Scotstown? I think they have much older equipment there”. The ‘biographies of use’ that develop around medical devices, and the ‘interactional histories’ that develop between staff and a machine, have previously been noted by Strauss et al. (1985). The ‘war stories’ (Orr, 1996) described here help to *create* biographies around particular pieces of equipment, while tales of other units allow the nurses to consider if things are as they should be, how the unit compares to those other units.

As well, there is an acceptance among the nurses of the situation in which they have to work, an acceptance of having to manage contingencies, both in relation to technology and more generally. Chapter 3 described how the need to manage contingencies has been noted as a defining feature of medical work. During observations at the first ICU, when a patient arrived from another hospital, the patient’s blood gases were measured. It became apparent that the blood gas measurements taken at the previous hospital were inaccurate, despite having significance for the treatment that had been given. Due to the problems of technology, data items previously deemed trustworthy suddenly become suspicious (Berg, 1997).

Another example that comes from the fieldwork, relating to the nurses’ routine troubles, was the case of a ventilator that had been lent to another hospital “overnight”. It was finally being returned three weeks later, which meant that the unit had no backup machine for three weeks. Equipment gets borrowed by other departments and then a search ensues to recover the missing device. (Similar stories are recounted by Strauss et al. (1985)). On occasion, the unit also has to borrow equipment from other departments. Again, these are routine troubles for the nurses.

5.3 Technical inexplicability

It is also apparent from the vignettes that nurses are accepting of a level of technical inexplicability in their interactions with the haemofiltration device. This is visible for

example in Caroline's comments that the device previously was not working for "some reason" and "because [the device] wasn't happy", and her inability to explain why, by the end of Vignette 5.1, it was working.

Such acceptance of the technical inexplicability is visible in their interactions with other devices as well. When a ventilator would not stop alarming and the nurse did not know why, she said to patient that it was "just the machine being temperamental." What counts as an explanation for nurses is very different to what counts as an explanation for, as an example, clinical physics technicians. It would not be possible to expect nurses to have a detailed understanding of the inner workings of the devices they use, and the distribution of knowledge relating to medical devices amongst nurses, clinicians, clinical physics technicians, manufacturers and distributors, means that nurses should not need such knowledge.

Yet it is not just the nurses who express an acceptance of technical inexplicability. The distributor's lack of answers has already been mentioned, and similar behaviour could, at times, be observed amongst technicians. When a technician from the biochemistry department finished looking at the blood gas analyser, he said to the charge nurse, "It's calibrated but I don't know if it's working...I've changed everything." It could be argued that if the information from technicians, manufacturers, and distributors seems 'confused', it justifies, and normalises, the nurses' own confusion. One of the nurses commented that sometimes the clinical physics technicians fix equipment but are unable to explain how they did it, while a clinical physics technician commented on how difficult it can be to explain to the nursing staff what they have done. Thus, it may not necessarily be that they do not know, yet the effect is still the same.

The acceptance of technical inexplicability can also be considered as an acceptance of uncertainty. The nurses accept that, just because a device is working now, it does not mean that it will work next time. Intensive care nurses are also used to dealing with uncertainty more generally. For example, during fieldwork at the first unit where observations were carried out, there were two cases where the consultants were unable to determine what was wrong with the patient yet still had to treat the patient. As Berg (1997) argues, medical practitioners are required to "seize upon opportunities in the midst of confusing circumstances."

5.4 ‘Try again’ approach

Because of their lack of experience with the haemofiltration device, it was difficult for the nurses to ascertain what they could expect in the behaviour of the device. As inexperienced users of the device and as non-technicians, they had limited methods for responding to problems. The fact that the device was new within the unit meant that there was no clear framework surrounding the device for dealing with problems. Within the renal core group meetings, such a framework was just starting to be established. Nurses therefore had to rely on their experience of other devices and their non-technicians’ methods for dealing with those other devices. They brought to the use of the haemofiltration device a set of ‘background expectancies’ (Heath et al., 1999), which render particular features of a scene noticeable, informing the way in which particular events will be noticed and accounted for. The characterisations of technology, as problematic and unpredictable, have led to particular ways of dealing with problems with devices, part of the normal, standard way of dealing with technology.

As is apparent from the vignettes, when the haemofiltration device produced error messages, whether in the self-test or during treatment, a common approach was to switch off the device and set it up again. In Vignette 5.1, even after the device was declared ‘evil’, Caroline still decided to try setting up the device again. This approach of ‘try again’ is described by Barley (1988), in his observations of CT scanner technologists, as one of the ‘ritual solutions’ used by the technologists in overcoming problems. It is also an approach recorded in the account of the Therac-25 accidents, where massive overdoses were given by a computerised radiation therapy machine (Leveson and Turner, 1993). It could also be argued that this is an approach that many of us use in other settings, like in the example of resetting a computer after it ‘hangs’.

At the time of the events described in the first few vignettes, the nurses did not have much experience with the haemofiltration device and so they were often concerned that any error messages were due to a problem with how the device was set-up. This tendency of operators, particularly less experienced operators, to take responsibility for technological problems when there is an absence of evidence to the contrary has also been noted before in Barley’s (1988) study of CT scanner technicians and in Bosk’s (1979) study of surgeons. The approach provided the nurses with extra opportunities to gain experience in

the set-up of the device. In the same way that doctors will sometimes provide a treatment and then establish the cause of the illness through the success or failure of that treatment (see Berg (1997) for an example of this), if the device worked the second time, the nurses could attempt to consider what they did differently to the first time and learn from that experience. As Garfinkel (1967) argues, and as described in the discussion of situated action in Chapter 3, often we do not know what we were hoping to achieve until we have achieved it. The goal, and the method for achieving the goal, are often established *post hoc* (Berg, 1997).

The ‘try again’ approach was not only used with devices where nurses lacked experience or confidence. It was a general approach that was used with various devices in the ICU. For example, on one occasion, a syringe driver came up with an error message that the nurses did not recognise. While one nurse went to get another syringe driver, the other nurse tried setting up the syringe driver again, and this time it worked. With the lab results computer, consultants, SHOs and nurses would all try several times in response to the recurrent ‘Busy please try later’ messages. (Although this would seem that the staff were just following the instruction, the staff stated that the message was meaningless). Such an approach does not provide the needed experience that setting up the haemofiltration device provided, but it remains as an acceptable first (or, in the case of the lab results computer, continuous) response to any technological problem whose cause is not apparent.

Berg (1997) describes a similar pragmatism, giving the example of the habit of waiting two hours when a patient’s temperature goes above the desired level and then checking the patient’s temperature again. This practical, informal routine is a local response to the fact that isolated temperature peaks are often innocent events. Adhering to formal rules would result in much unnecessary labour, requiring the physician to be notified and a sample of blood to be taken and sent off to be analysed.

Although they would presumably be viewed as failures of practice if they resulted in an accident, such approaches persist, often with what is considered to be a successful result, preventing extra work or inconvenience. It was an approach that allowed the nurses to get on with their job, without the need to wait for an engineer or clinical physics technician. Such methods provide medical practitioners with an *ad hoc* way of ‘separating the wheat from the chaff’ (Berg, 1997).

Barley (1988) argues that the try again approach breaks up the flow of action in a way that creates an illusion that one faces a series of problems, rather than different materialisations of the same malfunction. As was often the case with the haemofiltration device, once the ‘try again’ approach has been used, the previous error message or alarm often appears to have no significance, at least for the time being. Thus, the problem is ‘dissolved’ (Orr, 1996) without its cause being diagnosed and the acknowledgement of problems is delayed. With the haemofiltration device, the nurses were pleased when they appeared to have got it to work but were often no clearer as to the reason for the previous problem, apart from the regular assumption that it was a failure in their own previous actions. However, as described above, such randomness in the behaviour of a device was accepted by the nurses and they did not expect to know the cause of a problem. The significant result was getting the device to work.

5.5 Teething problems

The previous section introduced the notion of ‘background expectancies’ (Heath et al., 1999), which render particular features of a scene noticeable, informing the way in which particular events will be noticed and accounted for. It was argued that one background expectancy that nurses have is that technology is typically problematic and unpredictable, and this has led to particular ways of dealing with problems with devices. Another ‘background expectancy’ that the nurses brought to the use of the haemofiltration device was the expectation that, with a new device, there will be initial problems, ‘teething problems’ as they were referred to by Sarah in the renal core group meeting. However, it is expected that these problems will be overcome or will resolve themselves; ‘the truth will out’ (Gilbert and Mulkay, 1984). Teething problems can be considered as problems that are temporary and occur naturally at the start of something. The notion of teething problems allows the nurses to deal plausibly with problematic behaviour. It allows them to point ahead to the time when untold factors will be eliminated or will become told, a time when the device will no longer be a black box to the nurses (Gilbert and Mulkay, 1984).

This notion of teething problems amongst users has been referred to in studies of work in other technological settings (e.g. Rogers, 1994). Although we may consider it here as a non-technician’s explanation, it was also an explanation used by photocopier engineers in Orr’s (1996) study.

It was within the renal core group meetings themselves that the notion of teething problems became most strongly apparent. The attention focused on what the nurses could do, in terms of creating a local manual, providing training, recording problems. While this would not change the occurrence of the error messages, it did mean for the nurses that they were doing as much as they could do. Like the ‘try again’ approach, this approach allows nurses to get on with the work.

The use of the notion of teething problems can be compared to the ‘wait and see’ approach to diagnosis, that is, with difficult cases, waiting until further symptoms appear that fall into a more easily interpretable gestalt (Strauss et al., 1985). Such a ‘wait and see’ policy was also identified in the investigation into the Ladbroke Grove train disaster. It was found that signallers would wait before pressing the ‘signals on’ button, because most signals passed at danger (SPADs) are either rapidly corrected or are ‘technical’, meaning that the train passed the signal by only a metre or two (Law, 2000). Another comparison comes from Harper and Hughes’ (1993) studies of air traffic controllers, where they describe the air traffic controllers’ treatment of ‘routine problems’. If, for example, an aircraft failed to appear on the radar at the appointed time, it would not immediately be treated as cause for concern. Rather, the controller will assume that the radio and radar are functioning properly and will wait for further information to clarify the location of the aircraft. This is due to the fact that controllers know that there are many ‘good reasons’ why an aircraft does not arrive at the expected time. Such an approach benefits the nurses because it puts off the disruption of returning the device to the manufacturer, a disruption that the nurses consider could potentially be unnecessary.

We can compare this to the documentary method, a method often referred to by ethnomethodologists. Garfinkel (1967) argues that the documentary method is a method that is used by social scientists but that is also used by people in the course of their everyday lives:

‘To decide what he is now looking at he must wait for future developments...By waiting to see what will have happened he learns what it was that he previously saw.’ (p.77)

The nurses did not initially know whether there was a problem with the device or whether their troubles were due to their inexperience or incompetence. In this sense, we can see each use of the machine as an inquiry, into what is the cause of the troubles with the machine and whether or not they will be able to make it work. Each successful use of the machine, even if only temporary, can be taken by the nurses as a sign of the potential of the machine, as well as a sign of growing competence on the part of the nurses, which is not disconfirmed until it next fails. The nurses are attempting to learn which problems are genuine, serious problems and which ones are routine and can be easily compensated for.

Using the notion of teething problems allows the nurses to treat the behaviour of the device as ‘normal’, the problems as ‘normal problems’. We can compare this to Berg’s (1997) description of how a patient’s problem is transformed into a manageable problem, a problem that fits local expectancies and existing work routines, with data, organisational issues, medical criteria and so forth all shaping this transformation. A manageable problem is constructed, but it is always only temporary, “adequate-for-the-moment” (Heritage, 1984), changing as the situation changes and as more information is gathered.

The flexibility of the categories of normal and abnormal is a topic that has been much discussed, both within ethnomethodological studies and studies of medical work. Berg (1997) argues that medical data and medical criteria are constructed and reconstructed in relation to concrete situations. Hartland (1993), in her study of ECG analysis, describes how ‘normal’ is an achieved rather than a given characteristic of an ECG. A number of different contextual factors are taken into account, such as age, race, medical history, and body size of the patient. There is also widespread disagreement about the criteria for an abnormal ECG. Doctors and technicians also rely on past experience in order to interpret ECGs. Thus, while those involved in the interpretation of ECGs may know how to do it, they cannot always explain how they do it. As in Garfinkel’s (1967) study of the classification of suicides, Singleton’s (1998) study of the Cervical Screening Programme laboratory staff, and Hartswood et al.’s (in press) study of mammogram readers, what is defined as abnormal or significant has to be judged each and every time (see also Emerson, 1970a; 1970b). The consequence of the fact that a definition of normal can only be ‘for all practical purposes’ is that the meaning of normal and the position of the normal boundaries is open for negotiation (Hartland, 1993).

Berg (1997) argues that medical personnel do not attempt to create “true” images of nature. Rather, they attempt to create a meaningful difference for the purpose at hand – a result sufficient to direct the immediate course of action. Medical work is directed at finding an answer to what Garfinkel (1967) has called the “practical problem par excellence: ‘What to do next?’” The idea of teething problems provides an answer to this question. By treating the problems as ‘normal’ problems, the nurses could focus on their own practical efforts. As already described, the use of the notion of teething problems did not mean that the problems were ignored, accepted, or forgotten. Emphasis was placed on discussion and practical activities such as the creation of new local manual and the provision of training. (For another example of how medical practitioners attempt to answer this question, see Hartswood et al.’s (2003a) description of how toxicologists use the categorisation of patients to decide what to do next. The categorisation is not necessarily accurate but it provides a way forward within the particular context).

The idea of teething problems was supported by the representatives from the distributor. A representative from the distributor labelled the problems described by the nurse as “fairly standard”, on the “checklist” of expected problems, while on another occasion, she referred to “these little things that are causing problems”. We are presented with this idea of ‘normal’ problems. When a representative from the distributor came in at the end of October, he said that by the end of November, there would be new software and better service, and he told Sarah to “remain patient.”

However, over time, it became harder to treat the problems as ‘teething problems’. There was an expectation that the device would ‘grow out’ of its problems but this had not happened. It was in the conversation with the distributor at the end of October that Sarah talked of how the experience with the haemofiltration device had been “frustrating” and “disappointing”. She said that the group was “still trying to think positive” but that it “gets harder to justify” to the staff why they bought it.

After this conversation and the representative’s request that they “remain patient”, Sarah said that she thought that the problems with the haemofiltration device were due to the difficulties that they had adequately preventing coagulation of the patient’s blood. She said that they were being loaned another machine and that, if there were still problems, they would know that it was definitely not due to a problem with the machines that they had

purchased. One of the consultants said that would not be the case if the problems were due to a “design flaw” in the device. Sarah’s response to this was that she did not think it was due to a design flaw because other ICUs “down South” that had the device were not having problems. Thus, we see that the understanding of the machine and the criteria for accepting the machine are not only based on the ICUs own experiences but also on knowledge of the experiences of other ICUs. This relates back to the point made in Section 5.2 that tales of other units allow the nurses to consider if things are as they should be, how the unit compares to those other units.

In the November renal core group meeting, Sarah acknowledged that it was “difficult to be positive” because of the problems. At this point, both the machines were out of use because of the CPU messages that had appeared. Another device was on loan that ‘worked’ but still required a software upgrade. One of the nurses in the group had spoken to other ICUs that use the same device, to find out what chart they use for recording measurements associated with the treatment, and in the process she discovered that other ICUs were having problems with the device. Previously, the problems were ‘hidden’ (Westrum, 1982). By this, we mean that the nurses believed that the problems they were experiencing could not be too serious, because no one else was experiencing those same problems. The problems with the device had been treated as a form of “noise”, rather than a signal of something more serious to which the nurses should attend. At the end of the meeting, Sarah said that she was “still trying to convince [herself] that [they had] done the right thing”, yet she said that she was “fairly confident that it will [be okay]”, reminiscent of her earlier talk of ‘teething problems’. The call for action was to keep practicing, a call foreshadowed in the use of the ‘try again’ approach. Still, the problem was given limits, Sarah saying that “once they’re up and running, they’re minimal maintenance, as you know,” thus suggesting that the problems related to the setting up of the device.

5.6 De/problematisation

In investigating the source of their troubles with the haemofiltration device, in their persistence with the machine, the nurses did not always treat the device as problematic. At the time of the earlier vignettes, the nurses had not yet set the limitations of the technology. In treating their own lack of experience and expertise as the source of their troubles with the device, the nurses could plausibly move between treating the device as problematic and treating the device as promising. In Vignette 5.1, we saw how Caroline

moved from ever increasing frustration with the device to a sudden satisfaction. Despite being aware of the difficulties Caroline had experienced with the device, Ben pointed to how “impressive” the device looked. At the same time, he was still questioning of the behaviour of the device. In Vignette 5.4, Julia initially talked about the device in positive terms, but her attitude was not so positive by the end of the vignette. There is a sense in which the difficulty of using the device emphasises the complexity of the treatment and, when the treatment was given successfully, emphasised the nurses’ achievement.

In the October renal core group meeting, Sarah talked about the haemofiltration device as an opportunity for the nurses to extend their roles. The way in which the use of technology contributes to the sense of self (Turkle, 1995) and the construction of understandings of competence (Ribak, 2001) has previously been described in the literature. Within work settings, the way in which the introduction of a technology affects users’ roles has been considered, and the relationship between technology and personal and professional identity has been a prevalent concern in many papers exploring the use of medical technologies (Heath et al., 2003). For example, Novek (2002) has explored the way in which IT support tools for drug-dispensing can lead to a redefinition of both nurses’ and pharmacists’ activity.

Other studies have described the way in which the introduction of a new technology (using the term ‘technology’ in its widest sense here) has been used by practitioners as an opportunity to attempt to redefine their roles. For example, Singleton and Michael (1993) investigated General Practitioners’ relationship to the UK Cervical Screening Programme (CSP), it being their task to enrol women to take part on the programme. The procedure is portrayed in government documents as unproblematic. Yet the GPs who were interviewed, similar to the way in which members of the renal core group would move between describing the haemofiltration device as problematic and then describing it as straightforward, would problematise the procedure. For example, the GPs would describe obtaining an adequate specimen as ‘complex’, while simultaneously suggesting that one hundred per cent adequacy was possible. Thus, the GP plays his assigned role of enrolling patients, yet at the same time complexifies and redefines that role. Singleton and Michael point to the notion of ‘strategic problematization’, where the complexity of an issue is emphasised but in a specific way, in relation to particular concerns. Singleton (1998) also describes how the laboratory staff of the CSP highlight and then accommodate

discrepancies, such as GPs not filling in forms or specimen slides properly. Through this work, they negotiate and redefine their role as being skilled, emerging as worthy of increased status and resources. However, in the same way that the GPs had to find a balance between supporting the CSP and redefining their role within it, this requires ‘careful monitoring and management’ as exposure of instability could threaten the existence of the CSP and the lab.

An alternative view of the response to problems comes from studies of normalisation. Garfinkel (1963; 1967) shows that when actual events do not play out as expected, when events do not fit with people’s expectations, they often attempt to retain their sense of control by either denying that problems exist or by asserting that nothing drastic has occurred, engaging in ‘perceptual and judgemental work whereby such discrepancies are “normalized”’. Garfinkel uses examples of ‘surprising’ responses to greetings. People initially responded with bewilderment, and then restored ordinary and “reasonable” circumstances. While it does not seem that the nurses were normalising the problems with the device, what such studies point to is the way in which a ‘casual’ response to problems is an opportunity for members to demonstrate competence. This is on the basis that those who fail to treat situations and events as ‘normal’ are vulnerable to adverse consequences, such as claims of inadequacy (not understanding the situation or inability to deal with it) or of ‘making a fuss’ (Emerson, 1970a; 1970b). For example, Sudnow (1967) describes how in the hospital setting, death is not a ‘countable’ event for anyone but a novice. An additional motivation for treating the problems as ‘normal’ came from the need to demonstrate the purchase as successful to the consultants. As previously noted, the purchase of the haemofiltration device was unique within the unit in terms of being the first nurse-led purchase. The consultants had voiced criticisms of the purchasing decision made by the nurses, potentially threatening the possibility of further nurse-led purchases.

What this also points to is a tension that exists for the nurses. Section 5.2 described how nurses expect of themselves and of each other to manage the contingencies of their environment, and this includes managing technological problems. While nurses who do not treat problems with the technology as ‘normal’ can be treated as novices, the nurses also need to demonstrate their frustration with the device and make the problems with the device apparent to the distributors and manufacturer of the device, in order to obtain a solution to the problems that they do not have the expertise to solve themselves. We could

consider this as two conflicting local accountabilities. There is the local accountability for managing technological problems but there is also a local accountability to bring in expertise to help with those problems, which can require acknowledging the difficulties of managing the device without such outside expertise.

What we see is that, although the haemofiltration device did not initially allow the nurses to expand their roles in the way that they had hoped, through their response to the problems, they were able to demonstrate their competence. They were able to show that they can accommodate problematic technologies, that they are not fazed by such technologies.

5.7 Summary

This chapter has explored the introduction of a haemofiltration device into an ICU. It has shown how the appropriation of the device, particularly the response to problems with the device, was shaped by the local practices of the unit relating to the use of technology, and how the process of appropriation was shaped by the nurses' experience and expectations.

Chapter 3 proposed that the ethnomethodological notion of accountability could be useful in understanding the process of appropriation. As well as the renal core group nurses' explicit accountabilities relating to the haemofiltration device, regarding purchasing, training, liaising with the manufacturer and distributor, and the setting up and use of the device, there were also a number of local accountabilities shared by the ICU nurses that affected the process of appropriation. We can see the intensive care nurses as being accountable for persisting with problematic equipment and for managing the more general contingencies of their environment, arising from their professional accountability to provide adequate patient care. The introduction of the device provided the members of the renal core group with new ways to be competent practitioners and demonstrate themselves as such, ways that were not entirely expected by the nurses, arising out of the problems with the device as well as the device itself.

While this chapter has been concerned with the general process of appropriation, the following chapter will turn to the more specific topic of customisation.

Chapter 6 – Localising the technology

‘Without invention, there are no tools. Without reinvention, there are no uses.’

- Bikson and Eveland, 1996

Chapter 2 introduced the idea that customisation is an important part of the process of the appropriation of technology. The previous chapter described the introduction of a device into an ICU in order to show some of the difficulties of appropriation. This chapter describes several customisations that were observed during the fieldwork and shows how customisation is a practice used in the process of appropriation. By customisation, we mean those changes made by users themselves to the technology and its associated documentation and procedures.

As described in Chapter 2, there is a different level of control between the customising of medical information technologies and the customising of medical devices. Therefore, the kinds of customisations relating to medical devices that were observed during fieldwork were either changes to how devices were used, or pen and paper adaptations, such as the rewriting of user manuals. These typically did not affect the workings of the device, what the device did as such, but were simple customisations to ease use of the device.

The rewriting of user manuals was observed for most devices in each of the units. This would sometimes take the form of a ‘crib sheet’, or a fuller manual with diagrams, as occurred in the introduction of the haemofiltration device described in the previous chapter. The language would be adapted, unnecessary details removed, and diagrams added, to make them easier to understand. Information would be attached to equipment that is not often used, where nurses may forget what they have to do. It is also a way of ensuring that everyone knows about changes to the way a device is to be used. Frequently, post-it notes were attached to devices, detailing how to use them.

Other customisations include basic things such as an elastic band to keep part of a device in place, as was done with the central chamber of the haemofiltration device. There were also other forms of such local flexibility, such as the ‘try again’ approach previously described, which we could consider as a persistent customisation to procedures surrounding the various technologies.

The following vignettes are taken from observations and are intended to give a fuller sense of the customisations that were carried out and the context within which they were carried out.

Vignette 6.1

When a new type of ventilator was being supplied by another part of the hospital, the education coordinator visited the people providing the ventilator. The education coordinator was given a demonstration of how to use the device and she wrote down, in a step-by-step style, how to set-up and operate the device. She asked questions along the lines of “So if the doctor asks me to do x, I have to do y and z, yes?” Setting up the device was not considered to be straightforward. For example, the user has to hold the two buttons down for long enough to set the trigger, otherwise it goes to a set up that the nurses will not be using. The education coordinator was worried that if it is not used often, nurses, including herself, will forget these things. The manual was not looked at and neither was a copy of the manual given to the education coordinator.

The education coordinator later typed up the instructions she had written down and these were used to teach nurses how to use the ventilator, later being kept by the ventilator for reference. When the fieldworker commented to the education coordinator on the fact that she had not looked at the manual, she responded, “Manuals are a nightmare.”

Vignette 6.2

The device described in the previous chapter is designed to manage the delivery of heparin, an anticoagulant given to assist the haemofiltration. Management of heparin delivery is an important aspect of haemofiltration. However, the nurses put the heparin through a separate syringe driver rather than through the device because, if they put it through the device, they cannot stop the delivery of heparin once delivery is started.

Vignette 6.3

Portable vital signs monitors are used when transferring patients between wards, in order to allow continuous monitoring of patients. When a patient was being transferred to another ward, the monitor being used switched off, despite the fact that the battery was charged and should last for two hours. When the nurse switched the monitor back on, a message appeared, saying “BATT COND”. On returning to the unit, the nurse informed the ward manager. The ward manager looked up the error message in the user manual and found that the error message refers to the battery condition and means that the battery needs to be replaced. Whether or not the battery has been recharged, it must be replaced after the fiftieth time it is used.

Since this incident, they have found that if the same thing happens while transferring a patient, you can “trick” the monitor by taking the battery out and putting it back in, to “let it forget”. This allows the nurse to continue monitoring the patient while finishing the move to another ward. On returning to the unit, the nurse will then change the battery.

6.1 Customisation as a necessity

Mackay (1990), in her study of user customisation of software within office settings, talks of the ‘perceived costs and benefits’ of customisation that determine whether or not a user will customise a system. Mackay found that most people resisted spending much time customising because they are busy with more pressing tasks. Thus, although someone may significantly personalise their email program for example, such changes tend to be made gradually, over the course of several months and often even several years. In contrast, in all of the ICUs observed, despite being very busy, a lot of time was given to activities such as the rewriting of user manuals.

As with most customisations to user manuals, the creation of the crib sheet described in Vignette 6.1 was seen as a necessity, a response to the ‘nightmare’ nature of manufacturers’ user manuals. The education coordinator knows what a nurse will know, what a nurse needs to know, how they like their instructions, and whether there are local factors that need to be mentioned, relating to the particular way that the device will be used within that specific unit. With the haemofiltration device, one nurse talked to the

representative from the distributor about the difficulty of “trying to understand what exactly [the manual is] talking about” and about her desire to “put it in my language.”

Certainly, the problematic nature of user manuals is something that has been much written about (e.g. Orr, 1996; Bell et al., 1997; Wright et al., 1998), and Garfinkel (1967) and Suchman (1987) have demonstrated the impossibility of creating self-contained instructions. Instructions must always be followed, must always be made sense of in relation to the particulars of the setting and situation. Part of the guarantee of such local manuals is that someone within the unit has succeeded in their use of the particular device, using it in the way that is appropriate for the particular unit, by following those steps; the nurses do not fully trust the manufacturers’ standard manuals.

Similar customisations are reported in Bell et al.’s (1997) study of Xerox customer service engineers, which was introduced in Chapter 2. Discussion with the engineers highlighted the inflexibility of the service manual for different styles of use. Engineers talked of the incompleteness of the information provided in the manual and the difficulty of extracting the underlying rationale of the procedures.

Wright et al.’s (1998) study of customisation on the flight deck describes how pilots would annotate their personal copy of the quick reference handbook. Some pilots would even produce their own more comprehensive versions for personal use based on their previous experience. Annotations concerned why procedures were the way they were, modifications to procedures, addition of extra actions, the consequences of taking an action, the cause of a warning or condition, the consequence of a warning or condition, and the highlighting of important steps. On this basis, Wright et al. argue that procedures ‘are given a meaning against a background of systems experience and culturally constituted knowledge. [They] receive a new meaning within the community of practice adding both rationale...and detail’. They describe procedures as:

‘A representation of work of one community with the intention of making it visible to another. By making the work visible, an opportunity is also afforded for making it organisationally accountable, which is of interest to regulatory authorities and others who may be concerned with evaluating work practice.’

In this way, manuals are transformed from artefacts of formal accountability to artefacts of local accountability. This creates a manual that is trusted within the unit and matches the work practices of the unit. However, it also has consequences for formal accountabilities because, if the nurses are not using a device according to the manufacturer's instructions, the manufacturer cannot be held responsible for problems that result from that.

In fact, all of the customisations described in the vignettes were seen by nursing staff as a necessity because, without those customisations, the nurses' ability to do their jobs would be impaired and/or the quality of patient care would be negatively affected. The customisation described in Vignette 6.3 is an example of a customisation developed as a short term solution to the fact that it is difficult to keep an accurate record of how many times the device has been used. Without using this customisation, a nurse may find that she is unable to monitor the patient while transferring them between wards.

The previous chapter described how the appropriation of the haemofiltration device was affected by the nurses feeling that they were alone in managing the technology, that the manufacturer and the distributor were not going to be of much assistance. This feeling of being alone in managing the technology also has significance for the customisation of technology, because it increased the sense of 'necessity' of the customisations. Staff believed that, typically, manufacturers do not listen to their comments and that comments made to distributors do not get fed back to manufacturers. So, nursing staff learn to customise the devices, or how they are used, to get them to work *in the way that they want them to work*. In the words of one ward manager, nurses feel that they "almost have to be technicians".

It is not that nurses expect of each other to have the knowledge and skills that a clinical physics technician has. Rather, nurses expect each other to be able to find a way to deal with or overcome technological problems, whether it is with a technician's solution or a non-technician's solution. It is considered to be part of the job, something that the nurses see themselves as being accountable for. (Although not observed during the research reported here, Strauss et al. (1985) note the 'considerable minor repairing' done by nurses, with screw drivers, wrenches, and other tools being kept on the ward ready for use). The carrying out of customisations is part of being a competent practitioner and of

demonstrating oneself to colleagues as a competent practitioner. Making suggestions for customisations is not something that we can expect from less experienced nurses. However, for more experienced nurses this is an opportunity to demonstrate competence, showing an understanding of the complexities of their job and an ability to deal with them.

6.2 Accountability for safety

It is important to consider the customisations described in this chapter in relation to discussions about procedures and protocols within medicine. Protocols are increasingly being introduced within healthcare in an attempt to reduce the opportunity for error, providing what are considered by their proponents to be ‘tried and tested’ approaches. Thus, customising procedures for using devices is an activity that has consequences for the nurses’ accountability, and which also reduces the accountability of the manufacturers.

Certainly, there are a series of procedures surrounding the use of equipment to ensure its safety and these procedures are carefully followed. Particular devices are regularly calibrated, ventilators are changed at regular intervals so that they can be checked by the clinical physics technicians, and the blood sugar analyser is tested daily for accuracy.

However, other procedures relating to the use of devices were customised, with potential consequences for safety. It could be argued that the customisations described in Vignettes 6.2 and 6.3 are examples of the nurses not being accountable for safety, as could the nurses’ persistence with the haemofiltration device described in the previous chapter. Alternatively, it could be argued that this customisation and the persistence arise out of a concern for patient safety and patient care. The customisation and the persistence allow the nurses, or help them, to provide the necessary care. For example, the customisation to procedures described in Vignette 6.3 could potentially have negative consequences for patient care if, following on from the described error message, the nurse forgets to replace the battery on returning to the ward. However, the customisation does ensure patient safety in the sense that, following such an error message, it allows the nurse to continue safely monitoring her patient.

The initial decision to put the heparin through a separate syringe driver, described in Vignette 6.2, arose out of a concern for safety. As was apparent in Chapter 5, controlling coagulation of the patient’s blood is an important concern when providing haemofiltration.

Coagulation can prevent the ability to provide haemofiltration, so often the amount of heparin delivered is increased once treatment has begun. However, there are various side-effects associated with the use of anticoagulants including haemorrhage, meaning that it is important to be able to stop the delivery of heparin. When a patient was being given haemofiltration, with the heparin being delivered via the separate syringe driver, there was a case of syphonage. This meant that the patient was given a large dose of heparin, rather than the heparin gradually being delivered throughout the treatment. The nurses thought that this happened because the syringe came out of its carriage. There was no adverse effect on the patient, but the nurses filled in a critical incident form. They got the clinical physics technicians to check that there was nothing wrong with the syringe driver and reported the incident to the manufacturer of the haemofiltration device. In the December renal core group meeting, the nurses discussed this case of syphonage. Sarah said that there is a risk of syphonage with any equipment where there is negative pressure, but they would now give the heparin via a Gemini pump because it can withstand greater pressure. However, the Gemini pumps come with their own risks. They require more heparin, which is why Sarah was reluctant to use them before, but she said that they have to “balance the risks”. Sarah also said that they took a risk with the device in that it was new on the market, and therefore not a ‘tried and tested’ device, but it was worth it because they considered it to be “the best on the market”.

Balancing risks in this way is an accepted part of medical work. Chapter 3 described the way in which we are all faced with conflicting accountabilities, and accountability for patient care and accountability for patient safety are two accountabilities that the intensive care nurses have to balance. This is in fact a conflict that is prevalent throughout medicine, as medical interventions which aim to remove or lessen the threat of illness (surgical, procedural, pharmacological, mechanical) can threaten the safety of patients, whether or not they involve the use of technology (Strauss et al., 1985). For example, the life of a cancer patient is threatened both by the disease itself and from chemotherapeutic drugs used to control the disease.

Risk decisions also have to take into consideration the available resources. For example, Strauss et al. (1985) describe how, in an ICU with old machinery, staff attempted to match devices to the danger profile of the patient, so that a patient in a high risk condition was cared for on the more efficient equipment, but was shifted to older and less efficient

equipment as soon as he was no longer in such a critical condition. Within the ICUs observed, when a device is seen as problematic or does not fit with the working practices of the unit, the nurses have to consider which has the greater cost, to use the device as it is in the way defined by the manufacturer, to not use the device, to customise the device or its associated literature and procedures, or to try some combination of such measures. This points to an important difference between customisation as it is described generally in the HCI and CSCW literature and the customisation of medical devices. This difference can be seen as an issue of immediacy. The nurses need to overcome technological problems *now*. The feeling of being alone in managing the technology has already been highlighted as increasing the sense of necessity of the customisations. The nurses do not want to, and often cannot, wait until a technician is available.

6.3 Customisation as collaborative

As described in Chapter 2, previous studies highlight the collaborative nature of customisation (e.g. Mackay, 1990; Gantt and Nardi, 1992; Clement, 1993; Dourish, 2003). The creation of a crib sheet described in Vignette 6.1 was carried out by a single member of the unit, who was specifically responsible for training. However, in other cases, the creation of user manuals has been a collaborative affair, as with the creation of the user manual for the haemofiltration device. For this, several members of the renal core group came together to decide what should be in the user manual. On other occasions, the particular skills of staff members were drawn on. In one unit, a nurse who had done an art degree previous to training to become a nurse created a diagram of the ventilator, showing how to set it up and advising on appropriate alarm settings. In Vignette 6.3, a nurse discovered through chance a way to temporarily overcome the limitations of the device. This was then endorsed by the ward manager as an acceptable customisation to the defined procedures for using the device and subsequently passed on to other nurses. Thus, it seems that, typically, customisation in the ICU is also a collaborative procedure.

Fundamental changes to the way a device is used are unlikely to be carried out by an individual nurse without previously being discussed with other nurses. When one nurse was showing another nurse how to set up the haemofiltration device, the second nurse questioned why they were putting the heparin through the syringe driver. The point is that such customisations are not simply the *ad hoc* violations of a single individual, unquestioned by those around. It would be unacceptable for a nurse to make a

customisation, such as that described in Vignette 6.2, without consulting others. The customisations are discussed and count as noticeable events that are open to the questioning of others, meaning that nurses are held accountable for the customisations that they make, part of the more general way in which use of equipment is something that is subject to much discussion.

6.4 Summary

This chapter has considered nurse-led customisations of medical devices from the perspective of customisation as an opportunity to be a competent practitioner and to demonstrate that competence to others. As with the persistence with the haemofiltration device, customisations show the ability of nurses to accommodate, and compensate for, the limitations of the devices that they have to use. Customisation is a collaborative activity, carried out with a concern for safety and a desire to provide adequate care.

Several important differences between the customisation of technology as it is described in the HCI and CSCW literature and the customisation of medical devices are apparent. Firstly, there is the issue of immediacy. Nurses need to overcome technological problems *now*. They do not want to, and often cannot, wait until a technician is available. The second difference relates to the amount of time and effort that the nurses expend in making customisations. The nurses expend significant time and effort, in focused bursts, as opposed to gradual changes. The third difference relates to the motivation behind the customisations. The nurses are motivated not only by the idea that the customisations will make their work easier (as with the user manual, described in Vignette 6.1), but also by the desire to ensure adequate patient care and safety (as with the portable monitor, described in Vignette 6.3). The fourth difference that was highlighted was that nurses are locally accountable for making such customisations, part of their local accountability for managing the contingencies of their environment, which includes managing problems with the technology.

The following chapter will consider a customisable technology that is a fundamental feature of the ICU – the adjustable alarm. While this chapter has considered how and why nurses customise the devices that they use, the following chapter will explore the significance for the appropriation process of supporting such customisation through design.

Chapter 7 – An ‘alarming’ environment

Keith, the charge nurse, is on the telephone. He says, “Can you take that pump away that’s been here for about 36 hours? It keeps alarming. We’ve had to cover it in a blanket and stick cotton wool up its bum.”

- Field note

While the intensive care unit can at times be surprisingly quiet, anyone who has entered an intensive care unit will be able to vouch for the occurrence of several alarms all going off at once. The ‘alarming’ environment is a consequence of the technical developments that have transformed the task of patient monitoring and its associated equipment. As described in Chapter 2, each patient is attached to a vital signs monitor, which continuously displays different wave forms on the screen, representing the patient’s heart rate, arterial pressure, central venous pressure, and pulse oximetry saturation (the percentage of haemoglobin which is saturated with oxygen). For each set of data that is being recorded by the vital signs monitor, there are at least two alarms. There is a high alarm, which will sound if the reading goes beyond a maximum level that has been set, and a low alarm, which will sound if the reading goes below a minimum level that has been set. It is not only the vital signs monitor that has alarms. Each piece of equipment described in the introductory chapter has an alarm. The ventilators will also alarm if set limits are exceeded. The enteral nutrition pump and syringe drivers will alarm when the fluid is about to run out. The alarms on all of these devices are both audible and visible.

Alarms generally are used to draw attention to the fact that something is wrong, for example fire alarms and burglar alarms. The Equipment and Materials Users Association (EEMUA, 1999) definition of alarms states that ‘an alarm will indicate a problem requiring operator attention, and is generally initiated by a process measurement passing a defined alarm as it approaches an undesirable or potentially unsafe value’.

However, within the intensive care unit, this is not necessarily the case. There is frequently what is referred to in the literature as ‘false alarms’, where an alarm goes off when there is in fact no cause for concern. We can distinguish at least several types of behaviour that different alarms call for. While some alarms may indicate the need for clinical intervention, such as a sudden drop in temperature or heart rate, others may just keep the nurse responsible for the patient ‘up to date’ about the patient’s changing state. There are

also those alarms, such as alarms on the syringe drivers and enteral nutrition pumps, which, like a ringing telephone, can be considered simply as a summons, as a call for action, notifying the nurse that the fluid in the syringe driver or enteral nutrition pump needs to be replaced. These alarms typically go off in plenty of time, meaning that it is not necessary for the nurse to change the fluid at that exact moment in time, so perhaps even the notion of a summons is too strong. Rather, such alarms act as an audible ‘to do’ list.

In an attempt to reduce the number of ‘false’ alarms, i.e. alarms that have no clinical significance, adjustable alarms have been introduced, so that nurses are able to adjust the alarms to fit with the patient’s physical state. Dependent on the patient state, some alarms will be more important than others so nurses can adjust the alarm limits to reflect this. The only other way that such situation-dependent alarms could be achieved would be by using intelligent alarm management systems. Such systems require situation-specific information and far more reliable sensors than are currently available (Watson et al., in press).

There is a fear that ‘too many’ alarms have resulted in a situation where nurses silence alarms, ignore alarms, or are unable to recognise where an alarm is coming from (Strauss et al., 1985; Meredith and Edworthy, 1995). Certainly, early on in the fieldwork and before a better understanding of the setting was gained, it was easy to react with concern when a nurse did not visibly pay attention to an alarm. Such behaviour is also a concern in the areas of anaesthesia, nuclear power and manufacturing (Gaba et al., 1987).

For this reason, the adjustment of alarm settings by nurses is a practice that has come into question by the medical community. However, it is a widely practiced and accepted procedure in the intensive care unit. The widespread adjustment of alarms in this way seems to be unique to intensive care. For example, for anaesthetists in the operating room, the ability to adjust alarm limits is rarely used because the work involved in such adjustment is considered to outweigh the potential benefit of having the alarms adjusted (Watson et al., in press). This is especially true when anaesthetists have to conduct a list of short operations, because to personalise the alarm settings for one patient would require doing the same for all, or at least resetting the alarm limits to standard settings afterwards.

The response to alarms is a widely studied topic in many domains and the design of alarms has received much attention within engineering psychology, a result of the fact that alarms

are considered to be ‘one of the most essential and important interfaces between human operators and safety-critical processes’ (Shorrock et al., 2002). While studies have been carried out looking at how nursing staff respond to alarms, such as how staff manage to determine what type of device is alarming and what area of the unit the noise is coming from (Sanchez Svensson et al., 2000), a topic that has received little, if any, explicit attention is the actual practice of adjusting alarm limits. What are acceptable alarm limits? How are acceptable alarm limits determined? What reasons do nurses give for adjusting alarm limits? It seems that while much attention has focused on how the occurrence of ‘false alarms’ can be reduced through more effective design of alarms, there has been little consideration of how nurses deal with this phenomenon themselves.

Adjustable alarms have been introduced on the vital signs monitors and ventilators, and so it is on these technologies that this chapter focuses. The vital signs monitor presents visual representations, wave forms, of the patient’s state on the screen, showing their heart rate, blood pressure, central venous pressure, and pulse oximetry saturation. Thus, it could be considered that the monitor is largely doing the monitoring work but notifying the nurse if the readings go outside of a certain limit. The ventilator both monitors and assists the patient’s breathing, displaying the breathing pattern on the screen. Again, it could be considered that the device is largely doing the monitoring work but notifying the nurse if the readings go outside of a certain limit.

The vignettes given below provide some examples of the different practices surrounding the use of adjustable alarms. This provides a starting point for the discussion that follows.

Vignette 7.1

A patient’s ART (arterial pressure) alarm went off quite often throughout the day, as expected by the staff. Becky, a supernumerary nurse, was looking after the patient. Ben, the charge nurse that day, came over and used the recurrent alarm as an opportunity to talk to Becky about appropriate alarm settings. He said to Becky that low alarms must always be on, because otherwise the nurse would not know if the sensors were disconnected. However, the high alarm goes when taking blood from the patient. As the alarm is expected to go off when this is done, or in another case where it is known that a treatment will cause an alarm to go off, a

nurse can suspend the alarm for either forty-five seconds or three minutes. The charge nurse turned to the fieldworker and said, “But I must qualify that by saying that I’m experienced. How significant do I think that is? I’d say it is very significant.” Less experienced staff do and should set narrower alarm limits. He said that alarms go off all the time but “we get paid to be annoyed.” However, his concern was that it can worry patients, as they will not know whether or not the alarm is for them; they may not even be aware that there are other patients on the ward.

Vignette 7.2

A patient’s ventilator kept alarming. Marcus, the consultant on duty, was with the patient, trying to get the ventilator to stop alarming. He could not get the alarm limits high enough to stop it alarming and could not find a way to suspend the alarm. The patient was breathing at a rate of 72 breaths per minute (bpm) and the alarm settings go to a maximum of 70 bpm. Kate, the nurse who was looking after that patient, came over to the nurses’ workstation, visibly annoyed at Marcus’ intrusion. She said that Marcus’ attempts were “just trial and error.” Another nurse asked Keith, the charge nurse for that shift, what Marcus was doing. Keith replied, “Aye, doesn’t know what he’s doing.” Marcus told the ventilator to “shut up”.

Vignette 7.3

On the nurses’ workstation is a screen on which main readings and alarm settings for all the patients are shown. From this screen, Caroline adjusted the alarms for a patient from the main console, telling Lucy, the nurse responsible for that patient. While Lucy was on lunch, Caroline also reduced the patient’s ECG low alarm after the alarm went off. Later, Caroline reduced the ART low alarm from the console for a different patient, while the nurse responsible for the patient was at another bed space.

7.1 Monitoring work

Identifying and responding to alarms is part of the larger task of what Strauss et al. (1985) refer to as ‘monitoring work’, the task of monitoring both the signals provided by equipment and the signals visible in the patient’s outward appearance, and the act of

responding to these signals. Monitoring work is concerned both with monitoring the state of the patient and with monitoring the mechanical functioning of equipment. The monitoring of the patient state is designed to keep staff abreast of several ‘dimensions’. First, there is the monitoring of trajectory stabilisation or change, and how much change has occurred. Second, if negative changes are drastic, then clinical safety is at stake and that has to be monitored. Thirdly, there may be monitoring along dimensions which are not strictly medical but which can have consequences for the patient’s health, relating to the patient’s comfort and emotional reaction to the technology. The type of monitoring called for can vary along different properties, such as the frequency, duration, and intensity of monitoring, number of items being monitored, and number of dimension being monitored, dependent on the condition of the patient.

7.2 A situated activity

In the units where observations were carried out, when a nurse starts her shift, she will check what the alarm settings are on the monitor, and adjust them so that she feels comfortable with them. For example, if the nurse is anxious about her patient, she may set narrower alarm limits so that she is alerted more quickly to any deterioration in the patient’s state. Similarly, if the patient’s state changes during the shift, the nurse may again adjust the alarm limits to reflect this. Changes to alarm settings may be made after the morning ward round with the consultant, if the consultant advises that particular attention be paid to a specific measurement. Thus, alarm settings have a course and a biography, and are shaped by consultants’ instructions.

Alarms on the monitor can be silenced completely or they can be temporarily suspended for either forty-five seconds or three minutes. As mentioned in Vignette 7.1, one of the alarms on the monitor will always go when taking blood from the patient, so usually the alarm will be suspended for forty-five seconds before carrying out this brief task. With the ventilators, it is possible to temporarily suspend the alarm for several minutes. A ventilator will always alarm when clearing the patient’s chest, so usually the alarm will be suspended before carrying out this task.

A monitor alarm will be silenced completely if the nurse feels that the particular alarm is not important to her understanding of the patient’s state or if that alarm keeps going off but it is not significant for the patient’s state. However, as also described in Vignette 7.1, the

low alarms are rarely silenced because a low alarm can be a signal that the associated sensors are not attached to the patient.

It is important to note that even if an alarm is silenced, this does not mean that the nurse is not paying attention to the information that the alarm is related to. An experienced nurse is typically watchful and knows what to watch for. Also, hourly observations (the noting of measurements from the monitor onto a chart, referred to by staff as ‘hourly obs’ or ‘just obs’) mean that nurses will regularly be reading the information from the monitor.

Changing alarm settings is also a customisation that allows nurses to be able to get the job done with as little distress for patients as possible. As the nurse describes in Vignette 7.1, nurses are aware that alarms can worry patients because they do not know what the alarm means and whether or not it is for them. Not only are the beds in close proximity, so that it can be difficult even for the nurses to identify the source of the sound, it has been found that there is a tendency for patients to interpret all surrounding noise and activity as directly relevant to themselves (Smith, 1990). Visitors also respond anxiously to alarms, being already apprehensive about the state of the patient and further ill at ease due to the strangeness of the surroundings (Welch, 1999). The noise in itself can be stressful for patients; hearing may remain intact or even be heightened, yet tolerance to noise is lowered in sickness. Therefore, nurses adjust alarm limits so that alarms are not going off unnecessarily. If the number of alarms going off is limited, it is also easier to detect where the alarm is coming from, as well as creating a more peaceful working environment (when carrying out validation for this chapter, one nurse said she felt it was important to point out how annoying unnecessary alarms are to nurses). What we see is that nurses consider the context, not only regarding the state of the patient but also her concern for the patient and relatives’ comfort, the non-medical dimension described by Strauss et al. (1985), when deciding how to set alarm limits.

Thus, the setting and silencing of alarms is clearly a very situated activity. An important aspect of being an ICU nurse is monitoring the patient, with the assistance of technology. But the ability that the nurse has, which the technology lacks, is the ability to construct a sense of the state of the patient that is circumstantially sensitive and relevant. This ‘sense’ is constructed continuously, with regard to whatever material or social resources the nurse is able to draw on. There is no alarm setting that is always ‘right’, because what is an

appropriate alarm setting is dependent on the state of the patient at that particular time, the treatment being provided at that particular time, and the experience of the nurse. Rather, a nurse must draw on her knowledge of the patient state, her knowledge of the cause of alarms, and her concern for the patient’s and relatives’ comfort, in order to determine appropriate alarm settings, and the appropriateness of these alarm settings must be reconsidered in light of any changes to the patient state or treatment. This suggests that even if adequate sensors were available to produce intelligent alarm management systems, there are still contextual factors, that cannot be easily measured, that need to be considered.

As for the behaviour described in the literature as the ‘ignoring’ of alarms, it is those alarms which always occur and where the cause is not only known but is certain, such as the ventilator alarm going off because the patient’s chest has just been cleared or the monitor alarm going off because a sample of the patient’s blood has just been taken, that will be ‘ignored’ if not silenced beforehand. Bitan et al. (2000) raise the important point that, while intensive care nurses are commonly viewed as engaged in a supervision task in which they should respond immediately to alarms, alarms may not simply be stimuli to which one always responds. Because a nurse does not respond to an alarm or visibly acknowledge it does not mean she has not heard it. She monitors the machine’s signals by ear and its readings by eye (Strauss et al., 1985). The major motivation behind the use of auditory alarms is so that they can be detected when nursing staff are engaged in other tasks (Welch, 1999). For example, if a nurse is at the nurses’ workstation when her patient’s ventilator starts to alarm, she may glance over, notice that the patient is coughing, which is the cause of the alarm, and continue with whatever she is doing, perhaps writing her patient notes. The glance may be so quick that it is not noticed by those around her or by the patient’s visitors, who are wondering what is wrong and why the nurse has not come over. Or if a nurse hears her patient’s enteral nutrition pump alarming while she is away from the bed, she may go straight to get more feed without even looking towards her patient, before going back to the bed. Such alarms are not warning the nurse of a dangerous situation but are simply a summons for action.

Once such comprehensive ‘glances’ have been learnt, nurses can redistribute their attention to focusing on other tasks. In the example of the patient’s feed running out, the nurse saves time by going straight to the store room. These glances, these ‘economies of interaction’ (Heath and Luff, 1991), are the result of experience, distinguishing the

experienced from the beginner, and have been noted in a variety of work settings, from cafes (Laurier, 2003) to London Underground control rooms (Heath and Luff, 1991).

What becomes apparent is that there are a series of pieces of information that are commonly known to experienced members of staff that relate to the setting of alarms, such as what will cause an alarm to go off unnecessarily and what are appropriate alarm settings depending on the patient state. Such information provides for local understandings relating to which alarms matter, which alarms to pay attention to given a particular patient state, and which alarms it is safe and acceptable to ignore. What are considered appropriate alarm limits are established locally, and thus understandings of accountability are established locally.

7.3 A demonstration of expertise

In Chapter 5 of this thesis, the role of experience was highlighted as a resource for interpreting and responding to problems with the haemofiltration device, in terms of the background expectancies such experience provides. Background expectancies were described as rendering particular features of a scene noticeable, thus informing the way in which particular events will be noticed and accounted for. In all of the behaviours above, not only is the nurse drawing on the material circumstances to guide her actions but is also drawing heavily on her own experience. As emphasised by Strauss et al. (1985), while the reading of body and behavioural signals is taught to nurses during their training, monitoring with the assistance of technology is a task that is very much learnt ‘on the job’, as is much of a nurse’s knowledge of the technologies she regularly has to interact with. For an experienced nurse, the setting of alarm limits, both in terms of knowing what are appropriate limits and how to physically set those limits, is something that is done every day with little thought.

However, for a new nurse, knowledge of appropriate alarm limits is knowledge that must be learnt. The problem of alarms going off ‘unnecessarily’ is a problem whose importance cannot be appreciated until actually doing the job, when the consequences for patient comfort (and the comfort of relatives) and ease of detecting alarms becomes apparent. Learning appropriate alarm settings is knowledge that is learnt alongside many other pieces of knowledge that must be picked up when a supernumerary nurse starts working in an ICU. It is not ‘primary’ knowledge, in the sense that new nurses can simply set narrow

alarm limits until they gain more confidence at adjusting them. As well as learning about appropriate alarm limits, the physical task of setting alarm limits must be learnt, particularly with the touch screen monitors, where the nurse must not let her finger ‘go over the line’ (therefore adjusting the wrong alarm), which even very experienced staff may do.

Less experienced nurses and agency staff are less likely to silence alarms and often set narrow alarm limits because narrower alarm limits mean that a nurse will be alerted more quickly to any change in her patient’s state. This is characteristic of the caution shown more generally by new and agency staff, also demonstrated in behaviours such as staying with the patient as much as possible while more experienced staff will often spend some time at the nurses’ workstation to talk to colleagues or write their patient notes.

While falling too much into the stereotype of strained nurse-doctor relations, Vignette 7.2 hints at the way in which technology within the intensive care unit is seen by the nurses as their domain, as their area of expertise. It is mainly through experience, but guided by the practice of colleagues, that nurses learn what are appropriate alarm limits and what behaviours will cause an alarm to go off, and it is only through such experience that nurses gain the confidence to set wider alarm limits. In this way, the setting of alarm limits becomes a way in which nurses are able to demonstrate their experience and knowledge. As is apparent from Vignette 7.1, it would be considered inappropriate for an inexperienced nurse to set wide alarm limits, yet it is acceptable, even expected, for an experienced nurse to do this. Experienced nurses are locally accountable for adjusting alarm limits to what is considered to be appropriate for the patient. As with the customisations described in the previous chapter, adjusting alarm limits is part of being a competent practitioner and of demonstrating oneself to colleagues as a competent practitioner. As with responding to problems in a device’s behaviour, for more experienced nurses this is an opportunity to demonstrate competence, showing an understanding of the complexities of their job and an ability to deal with them.

It seems then that definitions of accountability are not just locally defined but are also defined in relation to the nurse’s experience. Previous studies of the use of situated shared information displays have shown how users use the information on the display to make sense of events and vice versa (O’Hara et al., 2003). Although not initially perceived as a

tool for supporting cooperative work, we can consider the vital signs monitors as a form of shared information display. They are used by other nurses to make sense of events. Local knowledge, about the nurse and her level of experience, is used to interpret what the frequency of the alarm really means; not that there is a problem or that the alarm settings are too narrow, but that the nurse is inexperienced and so has appropriately set narrow alarm limits. Thus, as with written texts, there is no essential meaning inside the ‘text’ of alarm settings ‘written’ on the monitor. They can only be read as being too low or too high in relation to the context of experience and patient state. This intermixing of local knowledge with information from the monitor allows an effective use of alarms that fits with a user’s level of experience, which would not be possible with a rule-based system that looked for ways to reduce the occurrence of false alarms.

7.4 Monitoring the monitor

In all of the units where observations were carried out, not only are the alarm settings visible on the monitor, but each monitor is also attached to a computer that is placed on the nurses’ workstation. The nurses’ workstation is typically placed somewhere near the middle of the ward and nurses will often be around this workstation, answering the telephone or writing their patient notes there. On this computer, particular readings for patients are shown and alarm settings can be viewed and adjusted. Thus, as well as a demonstration of confidence, alarm settings on a monitor can also be read by others as a demonstration of competence. What we have then is a situation where the nurse responsible has declared what she considers to be appropriate alarm settings for her patient, these settings are available to others through their visibility, both on the monitor itself and also on the nurses’ workstation, and thus the nurse can be held accountable for the settings she has chosen.

What is interesting is the nurses’ ‘mutual monitoring’ (Suchman, 1993) of each other’s alarm settings, carried out whilst performing their own tasks. This kind of ‘peripheral awareness’ (Luff et al., 2000a) where individuals are sensitive to colleagues’ behaviour while engaged in other tasks has been the topic of several studies in safety-critical settings, such as London Underground control rooms (Luff et al., 2000a), space shuttle mission control (Patterson and Woods, 2001), air traffic control (Harper and Hughes, 1993), airport ground operations rooms (Suchman, 1993), and emergency dispatch centres (Pettersson et al., 2002). Although the layout *allows* alarm settings to be seen, it is only when the monitor

alarms that the alarm settings become noticed by others, the noise encouraging the alarm settings to be noticed. The looking is motivated and driven by virtue of the sounding alarm.

Chapter 3 of this thesis introduced Murtagh’s (2001) study of mobile phone use on trains. The ringing of a mobile telephone in a public space can be said to be an accountable matter. The owner of the telephone is not only accountable to the caller, as is the case with landline telephones, but is also accountable to those who are co-present. There is a sense of what is an acceptable number of rings before answering the telephone and, after this number of rings, the mobile phone and its owner typically come to be considered by those around them as an annoyance. In the same way, a sounding alarm is an accountable matter. If a patient’s monitor keeps alarming, the other nurses will hear this. As with the example of the ringing mobile phone, frustration builds when another’s actions, or failure to act, lead to a distraction for others. Thus, the nurse is accountable to not only the patient and the patient’s relatives but also to the nurse’s colleagues. In this situation, it is acceptable for another nurse to silence or adjust the alarm if the nurse responsible for the patient is not at the bed space, as happens in Vignette 7.3. Such ‘second order monitoring’ (Strauss et al., 1985) is also justified by concerns for safety and patient comfort. So the alarming of the monitor acts not only as an alert to the state of patients, but also as an alert to the actions and competencies of other nurses.

7.5 Summary

This chapter has explicated the detail of the setting of alarm limits within the ICU. We can point to the adjustable alarms as an example of a technology that supported the nurses in their appropriation of it, by allowing the nurses to customise the alarm settings to fit with the local, situated ways of working, the needs of the patient, and the nurses’ own experience. This allowed the nurses to gradually develop their understanding of the meaning of different alarms and to set the alarms according to their understanding. The chapter described how the setting of alarms became a means for nurses to demonstrate their competence. Thus, the technology took on meaning at both an individual and a group level, having meaning not just for individual nurses but also for the nurses as a group within the particular ICUs.

What is an appropriate alarm limit has to be continuously reassessed, shaped not only by the patient’s physical state, but also the patient’s emotional state and the nurse’s level of

experience and confidence. Thus, in contrast to articles that have been critical of adjustable alarms in medicine (e.g. Meredith and Edworthy, 1995), we can see adjustable alarms as a positive example of a technology that can be easily adapted to fit with local understandings of accountability.

It has been argued that customisations inherently work against people’s ability to share conventions (Brown and Duguid, 1994), but as has been argued before (Trigg and Bødker, 1994) and as is apparent from looking at the use of adjustable alarms within the ICU, there is in fact a tendency to systemisation of customisations, so that customisations become part of local practices, rather than being *ad hoc* changes of individuals. Although nurses may set different alarm settings to their colleagues, those alarm settings can typically be seen as fitting with local practice.

Part 3 – Conclusions and Implications

Chapter 8 – Appropriation and customisation in the ICU

The research presented in the previous chapters was motivated by the question, ‘What work practices surround and support the appropriation and customisation of medical devices by nursing staff?’ In order to answer this question, this chapter summarises the findings of the previous chapters, organised in terms of the sub-questions identified in Chapter 2:

- What are the main difficulties of appropriation?
- What types of customisation occur and how are they carried out?
- Why does customisation occur?
- Is customisation a collaborative activity within the ICU, as it has been found to be in other settings?
- What distinguishes the practice of customisation as it is observed in the ICU from customisation as it is generally described in the HCI and CSCW literature?
- How are concerns for safety dealt with?

8.1 What are the main difficulties of appropriation?

In Chapter 2, it was stated that appropriation is a process whose effects cannot be completely anticipated (Bikson and Eveland, 1996). This is because the same device can be appropriated differently by different organisations and may also be appropriated differently by different groups within the same organisation (Huysman et al., 2003; Törpel et al., 2003). Therefore, it is difficult to suggest that the process of appropriation described in Chapter 5, surrounding the introduction of the haemofiltration device, will be the same as the process of appropriation for other devices and in other ICUs. However, it is still useful to identify the main problems that were experienced in the appropriation of the haemofiltration device.

Certainly, there were problems with the device, both in terms of malfunctions and more general limitations. However, this was expected by the nurses. What made this difficult was the lack of information and the contradictory information, from the device itself and the manufacturer and distributor, which meant that the nurses found it difficult to make sense of the device and the associated problems.

What is also interesting to consider is the way in which the nurses persisted with the process of appropriation, although it is difficult to argue whether or not this was positive. This persistence can be seen in relation to the nurses' experience of medical technologies, and their manufacturers and distributors, generally. The nurses were willing to persist with the haemofiltration device because they expected that there would be initial problems with a new device. Nurses are also locally accountable for managing the contingencies of the environment, which includes managing technological problems. An additional motivation for the persistence, but a very important motivation, was the fact that the device was seen as an opportunity for the nurses to extend their roles.

We can also point to the adjustable alarms as an example of a technology that supported the nurses in their appropriation of it, by allowing the nurses to customise the alarm settings to fit with the local, situated ways of working, the needs of the patient, and the nurses' own experience. This allowed the nurses to gradually develop their understanding of the meaning of different alarms and to set the alarms according to their understanding. The previous chapter described how the setting of alarms became a means for nurses to demonstrate their competence. Thus, the technology took on meaning at both an individual and a group level, having meaning not just for individual nurses but also for the nurses as a group within the particular ICUs.

8.2 What types of customisation occur and how are they carried out?

Clearly, customisation is an important part of both the introduction of a device and its continued use. In Chapter 6, a series of customisations – to devices, to manuals, to procedures surrounding the use of a device – were described. These customisations allow the nurses to get on with the task at hand, making their work easier (as with the user manuals) but also preventing unnecessary disruptions to patient care (as with the portable monitor, described in Vignette 6.3). Chapter 7 described a customisable technology that is fundamental to the functioning of the ICU – the adjustable alarm. Adjustable alarm limits allow the nurses to customise the alarm settings to fit with the local ways of working, the needs of the patient, and the nurses' own experience.

Thus, we see that the customisations vary in terms of the effort required to make the customisations, the extent to which the customisations are restricted by the design of the technology, and the potential consequences for patient safety. Nurses would expend

significant effort in creating new user manuals but paper is a flexible technology (O'Hara and Sellen, 1997) which affords such customisation. In the same way, changes to procedures can typically be made without difficulty, although they are of course limited by the procedures prescribed in the design of the associated technology. The extent of the consequences for safety of such customisations depends on the extent to which the new procedures vary from the original procedures and what aspect of use and maintenance the change relates to. There are also customisations that are clearly supported by the design of the technology, as with the adjustable alarm limits. Although requiring extra knowledge on the part of the nurses, such changes are easy to make, requiring little time and effort.

8.3 Why does customisation occur?

Chapter 6 argued that the reason that nurses are willing to expend so much effort in customising the technologies they use and the surrounding procedures and artefacts is that such customisations are seen as a necessity. The nurses are motivated not only by the idea that the customisations will make their work easier (as with the user manual, described in Vignette 6.1), but also by the desire to ensure adequate patient care and prevent unnecessary disruption to that care (as with the portable monitor, described in Vignette 6.3). Something that increased this sense of 'necessity' was the feeling of being alone in managing the technology. So, nursing staff learn to customise the devices, or how they are used, to get them to work *in the way that they want them to work*. It is considered to be part of the job, something that the nurses see themselves as being accountable for. There is a degree of immediacy. Nurses need to overcome technological problems *now*. They do not want to, and often cannot, wait until a technician is available.

Chapter 2 described MacLean et al.'s (1990) classification of technology users into 'workers', 'tinkerers', and 'programmers'. What we find in the ICU is that the nurses do not enjoy exploring the system in the manner that 'tinkerers' do, but unlike the 'workers', they do have an expectation that they will be able to customise the system, motivated by perceived need rather than interest.

8.4 Is customisation a collaborative activity within the ICU?

Customisations were typically carried out either as a group or by an individual but later becoming part of local practice. Fundamental changes to the way a device is used are unlikely to be carried out by an individual nurse without previously being discussed with

other nurses. Such customisations are not simply the *ad hoc* violations of a single individual, unquestioned by those around. The customisations are discussed and count as noticeable events that are open to the questioning of others, meaning that nurses are held accountable for the customisations that they make, part of the more general way in which use of equipment is something that is subject to much discussion.

8.5 What distinguishes the practice of customisation as it is observed in the ICU?

These customisations are similar to the types of customisations described both in previous studies of medical devices and in studies of customisation within the HCI and CSCW literature. There are, however, several important differences between the customisation of technology as it is described in the HCI and CSCW literature and the customisation of medical devices. Firstly, there is the issue of immediacy. Nurses need to overcome technological problems *now*. They do not want to, and often cannot, wait until a technician is available. The second difference relates to the amount of time and effort that the nurses expend in making customisations. The nurses expend significant time and effort, in focused bursts, as opposed to gradual changes. The third difference relates to the motivation behind the customisations. The nurses are motivated not only by the idea that the customisations will make their work easier (as with the user manual, described in Vignette 6.1), but also by the desire to ensure adequate patient care and safety (as with the portable monitor, described in Vignette 6.3). The fourth difference that was highlighted was that nurses are locally accountable for making such customisations, part of their local accountability for managing the contingencies of their environment, which includes managing problems with the technology.

8.6 How are concerns for safety dealt with?

Although we might understand the motivations behind such customisations, user customisation in safety-critical settings brings up difficult questions surrounding the safety of such customisations and whether we should be supporting or attempting to control such customisations.

The first point to make is that not all customisations are the same in terms of their significance for patient safety. For example, the findings presented in Chapter 7 suggest that adjustment to alarm limits is something that is typically under control, controlled not

just by the design of the technology (e.g. the maximum and minimum settings possible on the ventilator alarms) but also by the local practice of the nurses.

In contrast, the customisations described in Vignettes 6.2 and 6.3 do have more significance for patient safety. The practice of ‘tricking’ the portable monitor so that it thinks that a new battery has been put in allows the nurse to continue monitoring her patient while transferring them to another unit. However, if the nurse then failed to replace the battery on returning to the ICU, this could have consequences for the next time that the monitor was used. The practice of using a separate syringe driver to deliver heparin when providing haemofiltration did result in a critical incident. This did not have negative consequences for the patient but potentially could have.

Accountability for patient care and accountability for patient safety are two accountabilities that the intensive care nurses have to balance. When a device is seen as problematic or does not fit with the working practices of the unit, the nurses have to consider which has the greater cost, to use the device as it is in the way defined by the manufacturer, to not use the device, to customise the device or its associated literature and procedures, or to try some combination of such measures. Such risk decisions take into consideration the available resources. Customisations certainly are carried out with a concern for safety, and a concern for patient safety, in terms of providing ongoing and appropriate patient care, is often one of the motivating factors behind a customisation.

Berg (1997) has already argued that organisational features, patients’ needs and wants, financial matters and so forth are as inseparably interwoven with “medical” matters as decision criteria and examination data. Mundane issues play similar and equally essential roles as ‘serious’ issues. In the same way, safety work is thus not simply one concern for the nurses that can be distinguished clearly from other concerns and accountabilities. Rather, it is thoroughly enmeshed within the work and work practices.

8.7 Summary

The analysis of the ethnographic data presented in the previous chapters has shown that the appropriation of medical devices is not a straightforward process. In the example of the haemofiltration device, appropriation was made difficult by the lack of information and the contradictory information, from the device itself and the manufacturer and distributor,

which meant that the nurses found it difficult to make sense of the device and the associated problems. However, the nurses were willing to persist with the haemofiltration device because they expected that there would be initial problems with the device. An additional motivation for the persistence, but a very important motivation, was the fact that the device was seen as an opportunity for the nurses to extend their roles.

The analysis has presented customisation of medical devices within the ICU as a collaborative activity that is seen by nursing staff as being a necessity, one of their local accountabilities. The nurses expend significant time and effort, in focused bursts, as opposed to making gradual changes. The nurses are motivated not only by the idea that the customisations will make their work easier but also by the desire to ensure adequate patient care and safety. Customisations may begin as the *ad hoc* activity of a single individual but they are soon incorporated into local practice. Customisations are carried out with a concern for safety, and a concern for patient safety is often one of the motivating factors behind a customisation.

Chapter 9 – Designing for appropriation

If you start boxy and simple, outside and in, then you can let complications develop with time, responsive to use. Prematurely convoluted surfaces are expensive to build, a nuisance to maintain, and hard to change.

- Brand, 1994

Having considered the practices surrounding the appropriation and customisation of medical devices in the ICU, this chapter attempts to answer the second research question of this thesis, ‘To what extent should we be supporting the customisation of medical devices by nursing staff and how can we support it?’ The previous chapters have described various changes to devices and their use that are not supported by the design of the device. The data suggests that the customisations can have positive effects, allowing nurses to use the technology in a way which fits more closely with their work practice and which attempts to prevent disruptions to patient care. It is the intention of this chapter to use the data presented in this thesis to highlight possible ways for supporting the customisation of medical devices through design.

The discussion of whether or not to support customisation of medical devices can be compared in many ways with discussions in medicine about the role of protocols. Research has shown how medical protocols are continuously adjusted in order to fit with local practice and cope with local contingencies (Berg, 1997), similar to the way in which technologies and their associated documentation and procedures are customised. The proponents of medical protocols have argued that it is not a problem with the idea of protocols, simply that the protocols used are inadequate. In the same way, one could argue that if technology were ‘better’ in the first place, customisation would be unnecessary. For example, it could be argued that with better research, designers of the haemofiltration device described in Chapter 5 and Vignette 6.2 would know that nurses would want to change the rate of heparin delivery, and designers of the portable monitor described in Vignette 6.3 would know that it is impractical to expect a record to be kept of how many times the monitor is used. This would require a greater level of research on the part of manufacturers into the working practices of nurses.

However, the ‘requirements problem’ described in Chapter 2 would still remain. Users continue to find it difficult to define what they want, many requirements only come up

once the device is in use, and work practices change, meaning it will always be difficult for designers to determine all the functionality that will eventually be required of a device. To use the words of one nurse, “new patients produce new problems”, and therefore nurses are not necessarily able to specify beforehand what it is that they will require. As well, different locations have different requirements, the result of local practices and concerns.

For this reason, this chapter focuses on considering possible means for supporting customisation. This is carried out through an exploration of the sub-questions defined at the end of Chapter 2:

- What are the various means by which medical devices currently support the nurses in making customisations?
- What other means for supporting customisation of medical devices are suggested by the nurses’ practices?
- If greater customisation was supported, how could safety be ensured?

9.1 How do medical devices currently support nurses in making customisations?

Although there has been little academic research into the customisability of medical devices, such studies tending to stay in the safer domain of the office, we can see that many devices within the ICU are already in some ways customisable.

Chapter 7 of this thesis described the adjustable alarm limits on ventilators and monitors and the successful way in which these were used. Such customisations are quick and simple, in contrast to those customisations described that were not supported by the design of the technology. Adjustable alarm limits allow the nurses to use the technology in a way that is appropriate for the patient’s physical state, the patient’s and relatives’ emotional state, and the nurse’s own experience. They allow nurses to reduce the number of unnecessary alarms, thus reducing stress for patients and their relatives and creating a more peaceful environment generally. This shows that, in particular situations, supporting nurses in making customisations can have positive effects.

Nurses can also customise systems in terms of the form of treatment they provide, as with the haemofiltration device and with the ventilator. Such technologies have a variety of customisable parameters, allowing nurses not only to select the appropriate treatment but

also allowing nurses to set parameters such as the blood flow rate, as was the case with the haemofiltration device. Again, such customisations are quick, although they do increase the complexity of both the device and its treatment.

9.2 How else can customisation be supported?

Several means for supporting the customisation of medical devices are suggested by the nurses' practices. Firstly, the advantage provided by customisable technologies such as the adjustable alarms suggests that further customisability could be beneficial, allowing the nurses to further customise the technologies to fit with their own experience and the needs of the patient. Chapter 7 described the practices surrounding the adjustable alarms that ensure safe and appropriate use. This gives reason to suspect that the use of other customisable devices would similarly be surrounded by such practices. The significant effort expended by nurses in making customisations also implies that further customisability could save the nurses time and energy that could be better used elsewhere. Secondly, the nurses' customisations can be seen as 'design in use', which raises questions about the boundaries between design and use and suggests that a reassessment of where resources should be placed within the overall systems life cycle could be of benefit. Thirdly, the practice of the nurses points to the possibility of a more modular approach to design, allowing the nurses to bring together the elements of devices that are most appropriate for the particular patient. Finally, the way in which nurses gained from talking to nurses in other units, as with the haemofiltration device in Chapter 5, suggests that more means of communication with other units, such as through internet-based newsgroups and bulletin boards, would help nurses in their appropriation and customisation of devices. These possibilities are further explored below and related back to relevant developments in the fields of HCI and CSCW.

9.2.1 Customisable systems

Chapter 2 described the growing number of workplace studies that have emphasised the situated nature of work and the aim of these studies to develop systems that more closely reflected local work practice. However, it has been argued that a more fruitful approach may be to support the flexible nature of work by providing a 'medium' which can be customised by the users themselves to suit each user's needs and the detail of their work (Bentley and Dourish, 1995).

Within HCI and CSCW, much attention has been paid to the topic of customisability. However, despite Tom Moran's plenary talk on 'everyday adaptive design' at DIS2002 (Moran, 2002), interest in this topic has decreased in recent years as attention moves on to systems that are self-adapting, such as context-aware systems. Both approaches arise out of a dissatisfaction with the fact that the majority of current technological systems treat all people and groups identically (Greenberg, 1991), when in fact different groups operate in different ways in different settings, and groups are made up of individuals who also have different ways of working (Dourish, 2003). However, there are great limitations on what context-aware systems can do, because so much of what can be considered as important context in interactions with technology cannot be sensed by technology. This was argued in Chapter 7, with the adjustable alarm limits, adjusted in accordance with aspects of the context that are unavailable to sensors, such as the level of user experience, and the level of distress of patients and relatives. Therefore, this section brings the attention back to customisability, focusing on discussing the possibility of customisable systems for medicine, an area where there has been little consideration of what customisable systems could offer.

Dourish (2003) defines customisable systems as those that 'can be adapted and tailored by their users, to fit them to different situations in which they might be used' (Dourish, 2003, p.465). The majority of work on customisable systems has focused on customisable interfaces, where the actual functioning of the technology remains the same. Bentley and Dourish (1995) argue that what is needed is 'deep customisation'. They define such customisation in the following way:

'Customisation in this sense implies not only the ability to mould and manipulate structures within the system, but also the ability to appropriate them and use them in new ways; support for customisation is support for innovation.' p.137

They give email as an example of such a system, arguing that it can be considered as a medium, as opposed to a mechanism, because it can be adapted to support users' specific requirements. Rather than structuring activities themselves, email applications typically provide a flexible framework in which the activity can take place. Thus, for example, whether to save a copy of a mail is a decision for the user alone.

One model of deeper customisation that Bentley and Dourish (1995) propose is provided by systems whose functionality is *parameterised*, so that users can configure system behaviour by selecting from lists of alternative functions. Parameterised systems have in fact been around for a long time – in 1981, EMACS was reported, a system that had over one hundred parameters (Stallman, 1981). However, with so many parameters, to understand how or if a desired change can be made and what kinds of changes can be made requires a much greater amount of skill and knowledge on the part of the user.

Other systems have since been developed that aim to provide flexibility for the user through the use of parameters, while not requiring a great amount of extra system knowledge on the part of the user. Neuwirth et al. (1994) developed a distributed collaborative writing system that provided users with a set of *parameters of interaction*, leaving the decision of how to set those parameters with the users. As the system was designed to support collaboration, the parameters related to how users of the system would interact with each other, rather than how they would interact with the system. These parameters were designed to cover the standard dimensions of interaction – who, what, when, and how. For example, the parameters for sharing documents covered the size of what was to be shared (the whole document or different chunks of the document), when it was to be shared (whether it was to be automatic or upon request), and the speed at which the document was transmitted.

We can see the adjustable alarm limits described in Chapter 7 as working on a similar philosophy of adjustable parameters, although they only dealt with the dimensions of ‘what’ and ‘when’ – which signals a nurse would be notified of and when she would be notified about those signals, rather than who would be notified and how. In the same way that nurses can make such changes within certain parameters, we can imagine allowing other variations to these devices and others within a certain acceptable safety level. For example, the alarms could also be customisable in terms of the ‘how’ dimension. Nurses could select the sound an alarm will make, in order to make it distinguishable from other devices and also to make it clearer which bed space the noise is coming from. Thus, it would also be a customisation along the ‘who’ direction, helping to ensure that the appropriate nurse is alerted. Another example would be a customisable haemofiltration device where, rather than nurses putting heparin through the syringe driver where there is a risk of syphonage, the user could change that aspect of the system so that the heparin

delivery rate can be changed once treatment has begun. Thus, while the idea of customisable systems in medicine may initially seem a controversial suggestion, what is being argued for is simply an extension of the flexibility that is already provided by medical devices.

Allowing such customisations brings up questions such as what aspects of a system should be customisable and who should be allowed to make such customisations. This is discussed in Section 9.3.

9.2.2 Design in use

The unpredictability of work and the resulting unpredictability of technology needs and use pose serious problems for design. As Büscher et al. (2001) argue:

‘It undermines the illusion of some engineering software culture, such as that software has, in any straightforwardly operationalisable sense, requirements which can be specified, or that the information components can be logically modelled and that this will be sufficient for a successful working system.’ (p.22)

As was described in Chapter 2, there has long been discussion of the blurred boundaries between design and use, and between designers and users (e.g. Suchman, 1994; Trigg and Bødker, 1994; Törpel et al., 2003). We can consider the customisations made by the nurses as examples of ‘design in use’, or what Moran (2002) describes as ‘everyday design’.

Procter and Williams (1994) question the idea that all problems arise through some failure in design and that these problems can be fixed by paying more attention to design. They argue that the implementation process offers opportunities for direct involvement of end-users in systems development in their own working environments. As briefly mentioned in Chapter 2, one approach that is concerned with blurring the boundaries between design and use and with providing the user with more control over the system is co-realisation (Büscher et al., 2002; Hartswood et al., 2002). The approach emphasises a continuing cycle of design and revised work practice, taking place within the work setting, thus calling for long engagement. Its aim is to enable users to grow into a technology.

Following on from Procter and William's (1994) initial suggestions, the emphasis in co-realisation projects is on 'simple' technology, in the sense that the system should only provide the necessary functionality and that, where possible, use should be made of technologies that are already available, such as off-the-shelf packages. The intention is not to be a provider of 'bells and whistles' but the provider of something that will afford work. Thus, the approach draws on the concept of bricolage, which Büscher et al. (2001) define as 'designing immediately'.

An important aspect of the co-realisation approach is the idea of having an 'IT facilitator' (Hartswood et al., 2002). An IT facilitator installs the system and provides training. Following on from that, the facilitator continues to visit the site, possibly one day a week. The facilitator's regular visits mean that when problems are encountered, the users do not have to deal with them on their own. Such an approach goes some way to overcoming the requirements problem. A new system will typically change the work and the work processes, or certainly new work processes will develop to incorporate the technology into the work, and this can result in new requirements. As new requirements emerge, the facilitator can customise the system to incorporate these new requirements.

As well as being used in projects involving landscape architects and manufacturing firms (Büscher et al., 2002), co-realisation as an approach for development has already been explored in the medical domain. One use of co-realisation was in a three year project in a toxicology ward in a UK hospital (Hartswood et al., 2000; Büscher et al., 2002; Hartswood et al., 2002). The use of an off-the-shelf speech recognition system was explored for assisting members of the ward psychiatric assessment team in producing discharge and transfer letters. The technology was found to be difficult to use and was eventually abandoned. However, this was not treated by the proponents of co-realisation as a failure. Rather, the ward staff's move to typing was treated as 'a practical, situated, members' choice of a work-affording artefact' (Hartswood et al., 2002, p.285). The emphasis is not on getting a particular technology in use but in finding means to support people in their work, in a way that suits them.

A similar approach, applied in the medical domain, is described by Bardram (1998), who presents the introduction of a patient scheduling tool into a surgical department in a Danish hospital. The scheduler was produced as part of a participatory design (PD) project and, in

order to assist in the appropriation of the system, several changes were made by its developers after its introduction, in order for the system to more adequately reflect the working patterns and patterns of cooperation within the department. For example, the patient scheduler initially did not allow for changes to operation plans during execution of the plan. However, based on the analysis of the dynamic re-scheduling of operations due to diverse contingencies, part of the situated nature of work described Chapter 3, the system was redesigned to allow for *ad hoc* rescheduling.

Clearly, there are different issues involved when we consider medical devices as opposed to information technologies, and the practice of co-realisation is very far from the typical current practices of medical device manufacturers. Using off-the-shelf products is not an option in the development of medical devices. However, the idea of starting with a simple version and expanding it once users have gained some experience with the technology is an attractive idea. It is also an idea that has been explored in other fields of design, most notably architecture. For example, Brand (1994) argues that designs should start with a ‘small core building’ or a ‘large but rudimentary building’. Rather than spending the majority of the development money at the beginning of the project, less should be spent at the beginning and the rest of the money could then go into ‘prolonged, attentive growth and improvement’ of the original. This requires that more money than usual be spent on the basic structure, less on finishing, and more on perpetual adjustment and maintenance.

What is particularly interesting about this approach is its focus on the idea of membership. While following very much in the tradition of participatory design, co-realisation uses ethnomethodology’s notion of membership. It is argued that in order for the project team to be able to ‘work across the boundaries of production and use’ (Büscher et al., 2002), the facilitator must become a competent member of the setting. This is seen to be necessary on the basis that it is only through membership of a particular community of practice that we can fully understand what needs to be built and can evaluate what is built. As this thesis has emphasised throughout, local accountabilities have a significant relationship to how technologies are appropriated and used. It is only through long engagement with a community of practice that we can come to appreciate such local accountabilities and thus understand what members of that community require of the technology and require of each other in the use of the technology.

While groups such as device distributors and manufacturers' help lines could be considered in some vague sense to be facilitators, what such groups seem to lack is accountability, both formal and local. Throughout the thesis, it has been noted that nurses feel alone in dealing with technology. For example, Chapter 5 described the contradictory information provided by the help line and the distributor's lack of answers to the nurses' questions. Thus, to have a facilitator of the sort suggested by the co-realisation approach would require a radical change in manufacturers' and distributors' relationships with hospitals. If the facilitator role was to be taken over by technicians, this would also require a radical change in the organisation of staffing, when you consider that for the haemofiltration device described in Chapter 5, when a technician was required, he had to be flown over from Germany. But it would encourage a stronger relationship between manufacturers and users, which is beneficial for both, as manufacturers get to find out more, gradually, about the needs of their users. Brand (1994) makes the following comment:

‘Some say you should flee a building while it is being finished or remodelled. I recommend occupying it. Bad as the inconvenience and aggravation get, it's worthwhile for the fine-tuning that only presence at the worksite affords.’ (p.201)

‘Fleeing’ is a term which could be used to describe the approach of some manufacturers, or certainly that is how they might be described by the nursing staff. But the potential benefit of staying around is fewer expensive mistakes and designs that develop with the user's needs, experience, and work practice. Brand argues that such a process turns the occupants, or in our case users, into ‘active learners and shapers rather than passive victims’ (p.209). While it seems apparent from the central chapters of this thesis that the nurses were in no sense passive victims of the technology but were in fact very active in their approach to try to overcome what they considered to be the limitations of the technology, their ability to learn about the technology and to fit the technology to their needs and work practices was typically not supported by the design of the technology.

There is an issue of immediacy which seems more important when considering medical devices instead of information technologies. If the psychiatric assessment team experienced problems with the speech recognition system described in Hartswood et al.'s (2002) study, they could presumably revert to their previous methods for writing discharge

and transfer letters. However, an important aspect of medical device use noted in this thesis is that when a nurse experiences a problem with a haemofiltration device as described in Chapter 5, or when a nurse finds that the vital signs monitor attached to her patient is no longer monitoring as described in Vignette 6.3, she wants and often needs to find a solution at that moment in time. If the problem occurs on Friday morning, waiting until the facilitator returns on the following Wednesday is not an option.

What is not clear is who should take over the role of facilitator. The complex and specialised nature of medical devices makes such approaches difficult to apply in the medical domain. It would presumably be necessary to have a different facilitator for each device because of the specialised nature of the devices. It also does not seem likely that the distributors' representatives would have the necessary skills to make the kinds of changes suggested by the co-realisation approach. It is even questionable whether a technician would be able to make changes like that to a device 'on the spot'. This would require a radical change in how such devices are designed. However, the development of customisable systems as described in Section 9.2.1 would allow the technician to adjust the customisable parameters to fit with the needs of the users. With suitable support, this is perhaps something that non-technicians would be able to do.

In conclusion, it seems that approaches to design such as co-realisation could be an attractive model for the design of medical devices, in terms of increasing manufacturers' understanding of users and their needs and customising devices once they are in the setting to more closely fit with local needs and local work practice. However, as noted above, this would be a radical departure from the current relationship between medical device manufacturers and hospitals. More customisable systems would also allow for changes to be more easily made by a facilitator.

9.2.3 More modular design

Something which draws on both of the two approaches described above is the idea of a modular design for devices. In Vignette 6.2, where the nurses use a separate syringe driver with the haemofiltration device, they bring together two separate devices to take advantage of the functionality and benefit of each. Thus, an alternative solution to customisation is to further extend this approach used by the nurses, so that devices can more easily be used together. A disadvantage of medical devices at the moment is that they cannot easily be

brought together in this way. A more modular design fits with the notion of bricolage (Büscher et al., 2001) described in the previous section, with each device acting as a ‘small core building’ (Brand, 1994), providing just the necessary functionality.

There are moves within the medical community to encourage standardisation of devices, so that most hospitals will now purchase, for example, all their syringe drivers from the same manufacturer. This is considered to have benefits both in terms of safety, because staff should not come across a device that they are unfamiliar with, and cost, because manufacturers typically offer beneficial prices for such contracts. The approach being suggested here would require a much greater level of standardisation, requiring collaboration between manufacturers to establish appropriate standards, so that devices could more easily and more safely be used together.

This thesis has talked much about the notion of competence and displays of competence in relation to technology use. Because of a lack of standardisation in medical devices, competence in using one device does in no sense ensure competence in using other devices. A more modular design would require greater standardisation across manufacturers and this in turn would hopefully allow nurses to draw on their competence in using other devices when they are required to use a new device.

9.2.4 Newsgroups and bulletin boards

Chapter 5 mentioned the way in which one nurse contacted other ICUs that were using the same haemofiltration device, and this led to the nurses having a clearer idea of the cause of the problems (or at least knowing that the problems were not the result of their own inexperience). In all the units where observations were carried out, ICU staff were keen to have greater opportunities to share practice with other units. New staff arriving from other units was seen as one way of doing this, and one nurse had gone to work in an Australian ICU for a period of time, as part of a scheme to encourage sharing of practice on an international level.


Internet-based newsgroups and bulletin boards could provide a useful means of communication with other units. Newsgroups have been shown to enable people to share experiences, discuss a variety of topics, and to give and receive support (Preece, 2000;

Girgensohn and Lee, 2002). They overcome the barriers to communication of time and distance.

Research into online communities in the medical domain has focused on support groups for patients (e.g. Preece, 1998; Cheng et al., 2000). However, newsgroups for medical workers could be equally beneficial. Nurses could post details of problems they were having, in order to find out if other units were having similar problems and if they had found ways to overcome those problems. Nurses could share information about which devices they had found easy to use, or which manufacturers they had found to be helpful. This would help nurses to overcome one of the main difficulties of appropriation – the lack of information and answers from device manufacturers and distributors. Putting nurses in contact in this way also puts nurses in a more powerful position. One of the reasons that the nurses persisted with the haemofiltration device, as described in Chapter 5, was that they had been told by the distributor that other units were not having the same problems. When ICUs have easier access to information about the experiences of other ICUs, such problems can no longer be kept ‘hidden’ (Westrum, 1982) and ICUs are in a better position to demand improvements and changes from manufacturers.

9.3 If greater customisation was supported, how could safety be ensured?

Section 9.2.1 discussed the possibility of more customisable systems for medicine. Such an approach clearly has significance for safety. How to ensure safety while allowing greater customisation will be discussed in this section.

In considering the safety implications of customisable technologies, we can again return to the discussion surrounding the use of protocols in medicine. Proponents of protocols argue that protocols are an effective way to ensure best practice and increase safety. The alternative view treats protocols as inadequate representations of practice that have to be tinkered with in order to be usable, thus arguing that protocols *per se* do not increase safety (Berg, 1997). Rather, it is the practices that surround the use of protocols, the practices that e them workable, that increase safety.

The difference between written protocols and protocols as they are implemented in equipment is that written protocols are often high level and nurses can adjust their interpretation of a protocol to fit with the work, whereas equipment forces the nurse to

follow specified actions in a specified order. One could ask why we insist on a level of restriction in medical technologies that is not applied in the rest of medical practice. Like protocols, rigid medical devices deny nurses the flexibility they require when problems become difficult.

It is important also to remember the significance that local accountabilities play in the use and customisation of technology, a topic that has been discussed throughout this thesis. Technologies do not nullify the social conventions that regulate workplace behaviours, although they may alter them. By this, we mean that even without customisable technologies, nurses consider safety when making customisations to devices and act in accordance with local understandings of accountability. In the same way that nurses demonstrate competent behaviour through their interactions with patients, interactions with equipment are equally visible demonstrations of competence, or not.

If we accept that customisation happens whether it is supported by designers or not and that customisations are carried out with a concern for safety and a concern for local understandings of accountability, we can turn our attention to increasing the safety implications of customisations that are made. Customisations could be replaced by much easier and safer solutions, if nurses were able to change equipment. For example, Section 9.2.1 already highlighted the possibility of a customisable haemofiltration device where the nurses can change the system so that the heparin delivery rate can be stopped once treatment has begun, rather than nurses putting heparin through the syringe driver where there is a risk of syphonage.

Certainly, not all aspects of the system should be customisable, not only for reasons of safety but also because this places too many demands on the user (Greenberg, 1991). To establish which aspects of a system could be potential, and safe, areas for customisation requires greater collaboration between designers and potential users of the system. It becomes the designer's task, through discussion with users, to determine what parts of the system should remain immutable and what aspects should be customisable, and then to set reasonable constraints on the customisation allowed (Greenberg, 1991). Such constraints are important because, as Bentley et al. (1992a) argue within the context of air traffic control, displays need to remain understandable to colleagues at a glance.

There is also the issue of who should be able to make customisations. With adjustable alarm limits, there are clear benefits to allowing individuals to adjust the limits themselves. However, with some systems and some parameters, for example the choice of anticoagulant delivery with the haemofiltration device, it may be that it is only necessary for the ward manager or a clinical physics technician to be able to make this choice. If we were to move to the ‘facilitator’ model of manufacturer support described in Section 9.2.2, this is a change that could be made by the facilitator. This is tied in with the issue of whether certain parameters need to be set every time a device is used or more frequently (as with the monitor and ventilator alarms), or whether it is adequate to set the parameters to fit with the practices of the unit when the device is introduced and for those parameters to remain unchanged (unless, of course, there is a change of practice). This is a practice that is already used by one UK syringe driver manufacturer, where how to make a particular customisation is explained to just the ward manager and a clinical physics technician.

While providing more control, customisation also implies costs to the users of the device as devices get more complex (Bentley and Dourish, 1995). Various modes of use increase the amount that needs to be learnt about a device in a setting where time for training is already limited and where there are already a large number of devices to understand. It also creates the possibility of ‘mode confusion’ (Sarter and Woods, 1995). Customising a device takes time, but then this has to be balanced against the time that nurses spend customising devices that do not support such customisation.

A much trickier problem is the question of how to certify a customisable device in a safety-critical environment such as the ICU. Opportunities for customisation increase the complexity of devices. However, again we have to balance these concerns against the fact that devices are customised regardless. But perhaps we should be reviewing how we evaluate the safety of a device, whether the device is customisable or not. The Medical Device Regulations (2002) for the United Kingdom state that the performance of devices must conform to the essential requirements under the *normal conditions of use*. With customisable systems, the definition of normal conditions of use becomes much harder. Yet, as this thesis demonstrates, the definition of normal conditions of use is unclear with non-customisable devices also.

The limitations of current certification practices have previously been explored. In order to be certified, medical devices must undergo a quantitative, randomised control clinical trial. It has been argued that this ‘gold standard’ of medical device evaluations should be complemented with qualitative investigations (Hartswood et al., 2003b). This on the basis that the randomised control clinical trial misses the way in which the technology is used in practice, misses the detail of its use. Hartswood et al. (2003b), in evaluating a computer aided detection system for mammogram reading, used what could be described as an ethnographically-informed approach to evaluation. They followed the standard clinical trial approach but also closely observed the use of the system in the trials and the readers were then asked about their experiences of using the system. The research presented in this thesis suggests that such a qualitative approach to evaluating medical devices, complementing the randomised control clinical trial, would be beneficial for the evaluation of all medical devices. This is because the randomised control clinical trial does not uncover the problems that arise when a device is used in the setting, and it does not uncover the practices of use that emerge around a device when it is used in the setting.

This leads to a further implication of this research for evaluations of medical devices. Not only is it important for evaluations to consider how devices are used in practice, but this research suggests that such evaluations need to be repeated on a regular basis, because practice is continually changing. It could be made an agreement of certification that manufacturers monitor the practices of use. This brings the process of certification for medical devices closer to the certification process for therapeutic drugs. Drugs may be given pre-certification but then subsequent long-term trials are required, and the drugs are subject to a process of recertification after a certain time period.

9.4 Summary

This chapter has described three complementary approaches for supporting the appropriation and customisation of technology by users. Firstly, the development of customisable technologies was explored, highlighting how various medical devices are already customisable to an extent. Secondly, it was suggested that a reassessment of where resources should be placed within the overall systems life cycle could lead to medical devices which more closely match the needs and work practices of their users. This would involve using a process of design such as that advocated in the ‘co-realisation’ approach, and using the notion of a ‘facilitator’, who would visit the unit on a regular basis, assisting

users in appropriating the device and customising the new device. Thirdly, a more modular approach to design was suggested. Finally, the potential value of internet-based newsgroups has been highlighted.

These approaches have been explored within HCI and CSCW, and the process of co-realisation has been applied in the development of information technologies for the medical domain. However, none of these approaches has explicitly been considered in relation to the design of medical devices. This chapter has argued that these approaches could be complementary to the design of medical devices. In particular, this chapter has suggested that various medical devices are already customisable in certain aspects and that this is something that should be further extended. Such an approach would allow nurses to achieve the benefits that they currently achieve through customising devices themselves but would make such customisations easier and quicker, and could also go some way to increasing the safety of such customisations.

The most promising of the approaches suggested initially appears to be the use of approaches such as 'co-realisation'. Certainly, further customisable elements could be beneficial. However, many devices are already customisable in certain respects. Without further research, it is difficult to identify clear possibilities for other potentially customisable elements. The idea of a more modular approach to design is also appealing. However, the approach of drawing on the benefits of two separate devices was only witnessed with the haemofiltration device and this was the most obvious example of a device where the functionality could easily be broken down in that way. Further research may highlight more possibilities.

Chapter 10 – Conclusions

This final chapter begins with a summary of the research and results presented in this thesis. The theoretical ideas that played an important role in the research are then reviewed and the role of the theory in the research is evaluated. This leads on to a reflection on the research methodology. Suggestions for future research are given, and the thesis concludes with some final remarks.

10.1 Research summary

The present investigation explored the process of appropriation of medical devices within the setting of intensive care. Particularly, it focused on how nurses appropriated the devices through various customisation practices. The introductory chapters provided the background to the thesis, describing previous studies of technology appropriation and customisation, and workplace studies generally. The methodology was described, and the two main assumptions on which the analysis was based were explained. Chapter 5 described the introduction of a new device into an ICU, highlighting how the response to problems is a situated activity that draws on local understandings of accountability. Chapter 6 investigated how nurses customise equipment as a way of responding to the limitations of devices. Chapter 7 analysed the use of adjustable alarms in intensive care as an example of a customisable technology. It looked at the factors that nurses consider in the setting of alarm limits, how understandings of accountability are displayed in the setting of alarm limits, and how the setting of alarms is a way in which nurses demonstrate themselves as competent members. The analysis begins to reveal the detail of how the appropriation and customisation of technology, and the use of technology generally, is enmeshed within local work practices, particularly local understandings of accountability.

The previous chapter used the analysis to consider how appropriation could be supported within the ICU. Three complementary approaches for supporting the appropriation and customisation of technology by users were described. Firstly, it was suggested that a reassessment of where resources should be placed within the overall systems life cycle could lead to medical devices which more closely match the needs and work practices of their users. Secondly, the development of customisable technologies was explored, highlighting how various medical devices are already customisable to an extent. Thirdly, a

more modular approach to design was suggested. The appropriateness of such approaches for the development of medical devices was explored.

10.2 Approach revisited

This thesis used ethnography as its method of data collection, and the collected data was then analysed in what could be referred to as an ethnomethodologically-informed way. This was complemented by several approaches to validation, including the collection of data from several sites and the use of respondent validation. This resulted in a valuable rich picture of the appropriation and customisation of medical devices within intensive care, a topic that has previously been little explored.

Although time-consuming, on reflection this approach still seems preferable to less time-consuming approaches that fail to provide such detail. It has allowed for a description of appropriation and customisation that considers the way in which these processes are part of the nurses' local practices, rather than considering those processes in isolation.

However, there are limitations to the approach that was used. While Chapter 4 described what are widely considered to be the main limitations of ethnography, the following sections consider the limitations of ethnography based on a reflection of this research. Particular aspects of the approach and their associated limitations are considered.

10.2.1 Typicality and generalisability

The issue of the typicality and generalisability of the data is one that was introduced in Chapter 4. It cannot be proved that the findings presented in this thesis are true for all types of ICUs, or that they are true for all ICUs in the UK, or even that they are true for all Scottish ICUs. However, an attempt at this form of validation was made by carrying out observations in three different units in three different hospitals, and across two different hospital trusts and two different cities. Reports on the research were also given to nurses in ICUs where observations were not carried out, so that those nurses could comment on whether the reports fitted with their experiences. Thus, what is known is that the findings of this thesis are not unique to or linked to a particular unit, hospital or trust.

The main question of typicality arises over the data presented in Chapter 5. As stated in the chapter, the purchase of the haemofiltration device was not typical because it was the first

nurse-led purchase within the unit. In most ICUs, purchasing decisions tend to be consultant-led, with nurse input. It is likely that the appropriation of the haemofiltration device would have been different if it had been a consultant-led purchase, as the nurses' perceived need to demonstrate the success of the purchase was a significant factor in their persistence with the device. However, such persistence with devices has been seen with various devices where the purchase has been consultant-led, as with the other examples of persistence described in Chapter 5 and with the customisations described in Chapter 6, suggesting that the fact of it being a nurse-led purchase was only one of the reasons why the nurses persisted with the haemofiltration device in the way that they did.

The research presented in this thesis can be considered quite limited in terms of its timeframe. The total data collection period was three months, in comparison to other studies of appropriation such as those by Törpel et al. (2003) and Karsten (2003), both of which had approximately three years involvement with the organisations being studied. This can be considered as the result of a concern with validation. On finishing the first period of fieldwork, the concern was to collect data from further sites, as part of the process of validation.

A more constructive approach may have been to, after that initial period of fieldwork, spend longer analysing the data in order to determine the main themes and then collect more data from the initial site. This would have helped to further determine the typicality and the generalisability of the customisations that were observed. This would also assist in highlighting areas where adequate information was missing. This is an approach used in Grounded Theory (Glaser and Strauss, 1967). Although the method of analysis significantly drew on the approach of Grounded Theory, it was initially rejected as a suitable methodology because of the focus of the analysis on explanation rather than explication. However, it seems that there are benefits to be gained from its process of data collection.

Respondent validation was one method that was used to determine the typicality and the generalisability of the observations, and the benefits of such a method are reflected on below in Section 10.2.3.

10.2.2 Accuracy of analysis

It could also be argued that a limitation of this research is its focus on the nurses' perspective. However, it is the nature of ethnographic research to focus on the perspective of a particular group (Hammersley and Atkinson, 1995) and a decision was made during the analysis that it would be preferable to focus on one group, rather than provide a brief account of the behaviours of several groups within the ICU. Providing an in depth account of the behaviours of several groups did not seem a realistic possibility within the timeframe. Also, within the ICU, it is the nurses that are present all of the time, while the consultants and SHOs are often elsewhere in the hospital, so that the majority of data collected focused on the actions of the nurses. However, this focus on the nurses also creates a bias in the analysis presented, in the sense that, for example, the manufacturers and distributors are only represented through the nurses' views of them and their limited appearance within the field notes.

This leads onto another issue regarding the use of ethnographic data, but an issue which does not have to be considered a limitation. The story presented in this thesis is only one way of telling the story. This is not to invalidate the story presented but simply to acknowledge that there are events and views which it does not present (Suchman, 1995). Thus, the analysis presented here should be treated as being open to revision, as new data adds to the detail.

10.2.3 Respondent validation

As was mentioned in Chapter 4, for the respondent validation, it was not possible to get enough nurses away from the ward at the same time to discuss the report as a group, nor was it possible to interview nurses away from the bedside. Feedback came in the form of brief, informal discussions at the bedside. Largely, the nurses were in agreement with the analysis, occasionally pointing to aspects of the report that they felt needed to be further emphasised. It is quite possible that, if it had been possible to discuss the report with the nurses as a group or to discuss the report away from the bedside, greater feedback would have been given.

A limitation of the way in which the respondent validation was carried out was the long gap between the carrying out of fieldwork and the carrying out of the respondent validation. The respondent validation was carried out with nurses who the researcher had

previously worked with but not for almost two years, and with nurses who the researcher had never previously met or worked with. With the respondent validation for Chapter 5, there was this big gap between the fieldwork and the respondent validation because of a desire to have the analysis fully written up before it was given to the nurses for validation. With the respondent validation for Chapters 6 & 7, nurses who had previously been involved with the research were asked to be respondents, in order to see if the findings were true for other units. Because there was not a strong relationship there, because the researcher could not just ‘hang around’ as when doing fieldwork, it meant that it was not possible to talk to them more fully about the analysis. This suggests that, for future research, it would be more beneficial to write up the findings whilst doing the fieldwork and discuss it with those in the setting at the time.

However, the respondent validation as it stood was still worthwhile from the perspective that it gave those in the setting an opportunity for greater involvement with the work and it provided some level of validation of the analysis.

10.2.4 Explanation versus explication

The process of data collection and analysis also led to much consideration of the explanation versus explication debate that was discussed in Chapter 4. At the beginning of the research, the aim was to focus on explication. Although the focus has remained on explicating the details of appropriation and customisation of technology within the ICU, some explanation has also crept in. While it is important to preserve the details of a setting, it becomes apparent that explanation is important if we want to consider the consequences for design. For example, the implications for design of user customisation are very different if the customisations are due to poor initial design or due to changing work practices.

10.2.5 Significance

Another limitation of the thesis also results from the time-consuming nature of ethnographic work. This thesis has referred to several authors who have argued that the value of a workplace study should be evaluated by considering how ‘generative’ the work is, in terms of how insightful and productive the findings are in highlighting problems with current design approaches or identifying potential new practices for design (Crabtree et al., 2000; Roth and Patterson, in press). The recommendations made in Chapter 9 are

supported by the data presented in this thesis. The recommendations have not been implemented, so they remain as well thought out suggestions based on an understanding of technology use, rather than being tried-and-tested guidelines. However, as stated at the beginning of this thesis, the main aim of this thesis was to focus on providing detailed descriptions of the practices that surround and support the customisation of devices. This does point to an area for future research, developing a medical device that expands the customisability of current medical technologies.

More generally, this seems a good point to reflect on how workplace studies can inform design. The relation between ethnography and design has been much discussed. Typically, workplace studies have resulted in implications for design that are specific to the actual system studied or the particular workplace. Using such workplace studies to produce more general implications for design seems to be a greater challenge.

Coming up with general implications for design is particularly difficult in the medical domain. This is because medical devices are very specialised pieces of technology, each used in different ways and for different purposes. While, for example, observation of the use of the haemofiltration device described in Chapter 5 could have highlighted many problems with the design of the device and areas for improvement (relating to, for example, how to represent the state of the system), these recommendations would have been difficult to transfer to other devices. A problem in this sense was coming up with suggestions that extended current HCI knowledge, when many of the problems seemed to be caused by a failure to apply quite basic HCI knowledge (e.g. providing error messages that speak the users' language).

10.3 Theory revisited

As well as drawing on previous workplace studies, the research presented in this thesis is based on two main assumptions about the nature of human action and interaction. The first assumption is that we demonstrate ourselves as being competent members of a community by acting in accordance with a set of local understandings about how to act, and how to understand action, within that community. The second assumption is that human action is situated, dependent upon the social and material circumstances. This section reflects on whether or not those notions were appropriate to the research and how they affected the analysis.

10.3.1 Local accountabilities

From a pragmatic perspective, the notion of local accountability on which the thesis drew can be evaluated positively. The notion of local accountability was helpful for understanding how work practices develop around technologies and how work practices change in relation to new technologies. Within the medical domain, there is often an emphasis on formal, professional accountabilities. The notion of local accountability provides a way to balance this by attempting to understand people in terms of their own aims, as well as the aims of the organisation. This thesis maintains that local accountabilities are an important consideration if we want to fully bring to light the detail of technology appropriation and use.

It is important to remember that local accountabilities are contextual and continuously open to revision. There is a danger of talking about ‘definitions of accountability’, which fails to reflect not only the changing nature of local accountabilities but also the vagueness of such accountabilities. This vagueness means that local accountabilities can be interpreted in a variety of ways by members.

10.3.2 Situated action

The notion of situated action was clearly appropriate for a study of the medical domain. As with previous studies of customisation, it provides a means to understand and explain the many workarounds that are identified in workplace studies, as users attempt to overcome the procedures that are inscribed within the technology. It also provides a balance to more formal views of medical work and the implications that has for understanding technology use.

However, a limitation of drawing on the notion of situated action is that it can lead to over-emphasising the situatedness of technology use. Customisations to technology and the procedures surrounding technology use are often ascribed to situated work practice, as was the case in this thesis. This focus can mean that more basic problems get ignored, the more fundamental failures in design which lead users to customise the technology and its procedures. The topic of whether customisation would still be necessary if the technology was better was explored early on in Chapter 9 and it was argued that customisation would still be necessary because of the changing nature of medical practice and work practice more generally, and because of local work practices. While this thesis maintains that it was

appropriate to focus on situated action as a motivation for customisation, it is acknowledged that there were also more basic problems regarding design that encouraged certain customisations.

10.4 Suggestions for further research

Two main areas for further exploration arise out of the research presented in this thesis, one technical and one theoretical. As discussed above, the recommendation for more customisable devices in the medical domain is a well thought out suggestion based on an understanding of technology use, but it is far from being a tried-and-tested guideline. Thus, one area for future research is the development of more customisable medical devices and the study of how such technologies are used.

From a theoretical standpoint, another area for further research is the issue of accountability and how it relates to technology use. This thesis has argued that local accountability is an important consideration if we want to fully bring to light the detail of technology appropriation and use. As described in Chapter 3, local accountability and its relation to technology use has been explored by several authors in the fields of HCI and CSCW over recent years (e.g. Luff and Heath, 1993; Dourish, 1995; 2001; Button and Sharrock, 1998; Eriksén, 2002). In turning to design, work that has come out of ethnomethodological notions of accountability has focused on the role that accounts of action play in enabling interaction, providing others with the means to understand the action and how to respond. For example, Dourish (1995; 2001) has explored the way in which systems can provide accounts of their actions to users, so as to support user interaction with the system, moving attention ‘away from simply the perceived result or outcome of an action, to include how that result is achieved’ (Dourish, 2001, p.80). However, this approach focuses on the system’s accountability to the user, which seems to move away from the notion of local accountability, being concerned with accountability to ‘others’ rather than accountability to ‘members’. Hartswood et al. (2003b) also question whether the representations provided by a system could be adequately contextualised in a manner that would enable users to draw on them in any meaningful sense. They make the argument that ‘such representations are not accounts in themselves but *resources* for the realisation of accounts by society members’ (p.389).

What has not been adequately explored is how the introduction of technology affects local accountabilities and how local accountabilities affect technology use. In Chapter 5, it was argued that local accountabilities affected the introduction of the haemofiltration device. For example, the nurses were locally accountable for managing the contingencies of their environment, including managing problems with technology. This local accountability can be seen as contributing to the nurses' persistence with the haemofiltration device. As was described with the setting of alarm limits in Chapter 7, new local accountabilities arise around technologies. For example, there were a series of local accountabilities surrounding the use of the adjustable alarm limits, relating to what alarm settings are appropriate for a particular patient, what alarms it is acceptable to ignore, and when it is appropriate to silence an alarm. However, while this thesis has considered the topic of how local accountabilities affect technology use and vice versa, its consideration is far from comprehensive and the significance for design remains unclear. As described in Chapter 3, it was out of concern for maintaining methods for local accountability when installing an electronic system that Hartswood et al. (in press) observed how mammogram readers demonstrated their competence through form filling procedures. Following McCarthy et al. (1997), the research presented in this thesis suggests that the requirements for the design of high-consequence work systems should be informed by understanding both local accountabilities and more formal accountabilities and the conflicts that arise between them, as such local accountabilities clearly affect how technologies are appropriated and used. But the significance of local accountability as a concern for design is still unclear. Questions to be explored include whether or not we should support people to demonstrate themselves as accountably competent members through the use of technology and, if we should, how do we go about it?

10.5 In conclusion

This thesis has drawn attention to an important but previously little explored topic: the customisation of medical devices and their associated documentation and procedures. What has been apparent throughout the thesis is the nurses' willingness to persist with the technology. We are reminded of Hartland's (1993) comment on the 'charitable' nature of medical practitioners towards the technologies that they use. The nurses' persistence can be seen in relation to the nurses' experience of medical technologies, and their manufacturers and distributors, generally. Nurses are also locally accountable for

managing the contingencies of the environment, which includes managing technological problems.

A series of customisations were described in the thesis – customisations to devices, to manuals, to procedures surrounding the use of a device. These customisations allow the nurses to get on with the task at hand, making their work easier (as with the user manuals) but also preventing unnecessary disruptions to patient care (as with the portable monitor, described in Vignette 6.3). A customisable technology was described that is fundamental to the functioning of the ICU – the adjustable alarm. Adjustable alarm limits allow the nurses to customise the alarm settings to fit with the local ways of working, the needs of the patient, and the nurses' own experience.

Customisations were typically carried out either as a group or by an individual but later becoming part of local practice. Fundamental changes to the way a device is used are unlikely to be carried out by an individual nurse without previously being discussed with other nurses. Such customisations are not simply the *ad hoc* violations of a single individual, unquestioned by those around.

These customisations are similar to the types of customisations described both in previous studies of medical devices and in studies of customisation within the HCI and CSCW literature. There are, however, several important differences between the customisation of technology as it is described in the HCI and CSCW literature and the customisation of medical devices. Firstly, there is the issue of immediacy. Nurses need to overcome technological problems now. They do not want to, and often cannot, wait until a technician is available. The second difference relates to the amount of time and effort that the nurses expend in making customisations. The nurses expend significant time and effort, in focused bursts, as opposed to gradual changes. The third difference relates to the motivation behind the customisations. The nurses are motivated not only by the idea that the customisations will make their work easier (as with the user manual, described in Vignette 6.1), but also by the desire to ensure adequate patient care and safety (as with the portable monitor, described in Vignette 6.3). The fourth difference that was highlighted was that nurses are locally accountable for making such customisations, part of their local accountability for managing the contingencies of their environment, which includes managing problems with the technology.

In considering the customisation of medical devices in intensive care, this thesis has emphasised the role of local accountabilities in affecting the use of technology. However, there is still much more work needed to understand the complex relationship between local accountabilities and technology appropriation and use.

In conclusion, this thesis has explored an important and previously little explored topic, the appropriation and customisation of medical devices in the ICU. A strength of the research is the fact that it is based on naturalistic observation within the setting, allowing for detailed description of the practices that surround such appropriation and customisation. Such an approach has allowed a broader perspective than previous research that has focused on issues of error relating to technology use within the medical domain. Finally, a significant contribution of this research, in contrast to research which uses ethnography to come up with design suggestions for a particular device, is that it demonstrates how ethnography can be used to reflect on design more generally.

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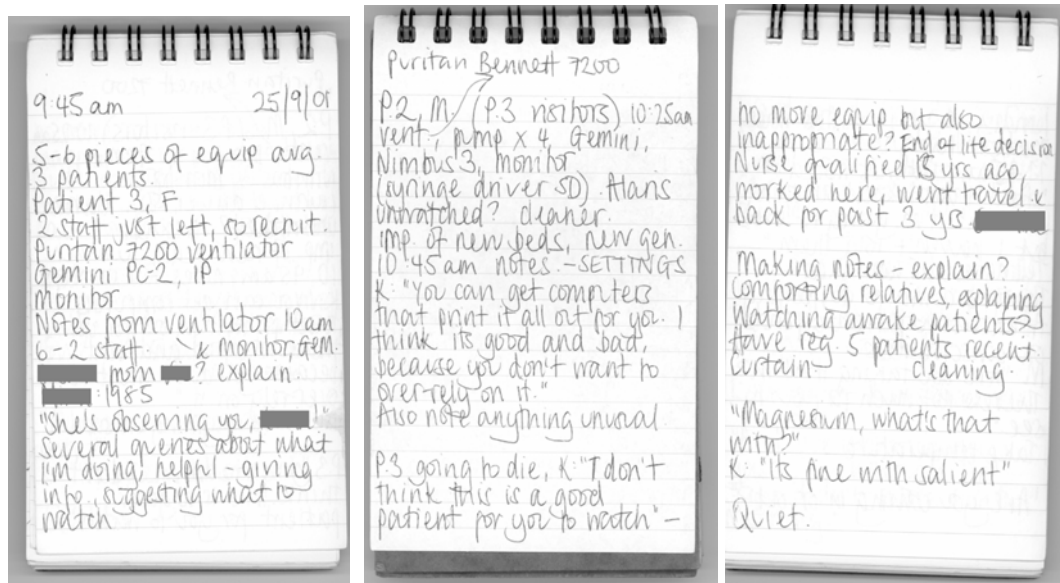
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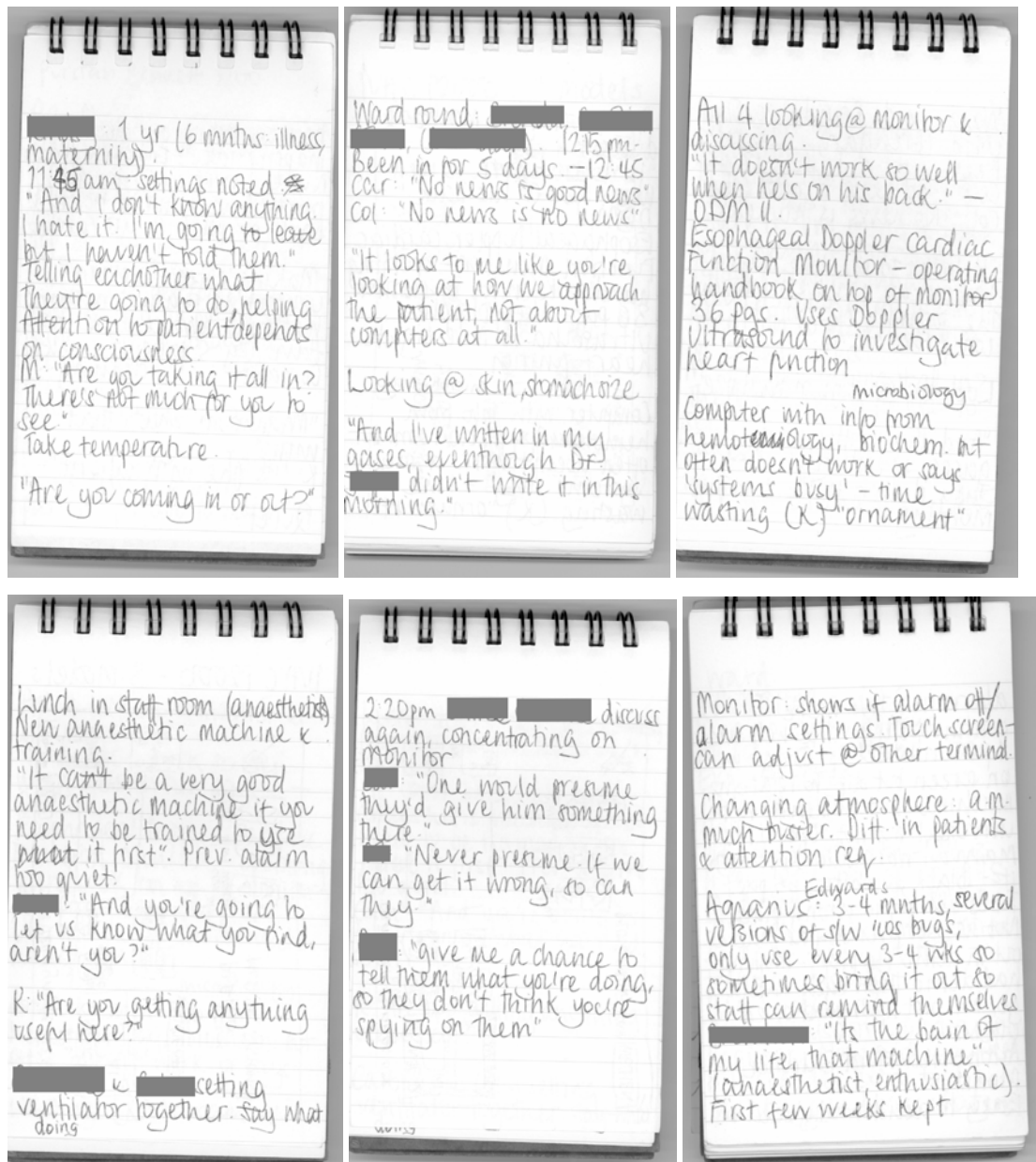
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Appendix – Field notes extract

In order to give the reader a clearer idea of the nature of the field notes taken during the observations, this section presents some field note extracts. Firstly, several pages of hand-written notes from the first day of fieldwork are presented. These notes are presented without editing, but names of members of staff and of hospitals have been blanked out. Then, an extract from the typed field notes are presented, covering the first two days of fieldwork. These notes are presented without editing, apart from the changing of staff and hospital names. Please note that these field notes were written for the author's own use, rather than being written for someone else to later read, hence the incomprehensibility of some sections.

A – Hand-written notes





B – Extract from typed notes

Week 1

Tuesday 25th September (Day 1)

I arrived at the hospital shortly after 9 a.m. The sister was not around, so one of the nurses took me to the staff room. I sat with another nurse, Nicola, and had a cup of tea and talked about what I would be doing. Joan arrived. At 9:45 a.m., I went to the ward and Joan told me a bit about each of the patients so that I could decide which patient to sit with. There were three patients in the unit.

I sat with a female patient (patient 3). She was attached to a ventilator (Puritan Bennett 7200), a Gemini PC-2, a syringe driver (IVAC P2000) and a monitor. The monitor shows if any alarms are off and what the alarm settings are. It has a touch screen and can be adjusted from the main console. The monitors are always placed behind the patient, meaning that the patient can't see them. The ventilator doesn't show alarm settings. According to Nicola, the ventilators they had in 1985 were "like a washing machine". They then had ones "with bellows like you see in American films". Various adjustments have been made to the new version of ventilator, such as placing it on the left instead of the right side of the bed but staff could not work with it on the left. Not all ventilators have screens, though they are trying to get them for all machines. Hourly, the settings of the ventilator and any significant data are recorded by the nurse. This is done for each patient, although it isn't always on the hour, if a member of staff is on break or is needed to help with something else. Patient 3 was in an unstable condition, so that there were between 2 and 6 members of staff with her at any time.

On average, each patient has five to six pieces of equipment. They have regularly had 5 patients in the unit recently.

Nicola: "She's observing you, Mike!" "Are you taking it all in? There's not much for you to see." (When I arranged to come into the unit, Lisa said to come in a week later to "give me a chance to tell them what you're doing, so they don't think you're spying on them.")

James: "I think you're looking at how we approach the patient, not about computers at all." "And you're going to let us know what you find, aren't you?" Mike: "Are you getting anything useful here?" Jane talking with me and Nicola: "We don't know what she's writing about us... Nicola talks a lot but she knows her stuff, whereas Jane doesn't know anything." I told Nicola and Jane that they could look at my notes if they wanted. Nicola to Caroline: "Rebecca's writing about your management performance."

Everyone asked about what I was doing and they were helpful, giving me information with and without my request. I said that I was a PhD student in the Computing Science department at Glasgow, looking into the use of technology in intensive care.

At 10:25, patient 3 had visitors, so I moved to patient 2, to allow the visitors privacy (as asked by staff members). Patient 2 was male, and attached to a ventilator, four syringe drivers, a Gemini, a Nimbus 3, ODM II (Caroline: "It doesn't work so well when he's on his back") and a monitor. He was in a stable condition and often was unobserved. The syringe drivers were all IVAC P2000s, although there were 3 different models, despite the fact that the sisters had told me that all equipment was standardised, bringing up the

subject of levels and definitions of standardisation. However, there is standardisation in the way dosages are represented. On the start and stop buttons, one model used symbols, whereas the other models labelled the buttons. They work pretty much the same, although two of the models can tell the syringe size, whereas with the other model, the syringe size has to be entered by the nurse. The ODM II is an Esophageal Doppler Cardiac Function Monitor, which uses Doppler Ultrasound to investigate heart function. The operating handbook is kept on top of the device (36 pages).

Nicola is a staff nurse, in her late thirties, and has worked at the ICU since 1985. She says that she would like a change of job because the ICU has changed a lot since she's been here. They used to get lots of burns, spinal and vascular cases, whereas these cases now go to more specialised units, so that Nicola feels she is losing some of her skills. According to Nicola, the ICU gets what the [Hospital X] doesn't have space for, and the ICU at [this hospital] might get closed. "They get all the glory." They get fewer students than they used to, so that Nicola feels she is losing her teaching skills. Nicola is keen to show me things. She talks a lot and would be a good person to sit with in future (a case of the researched picking the researcher).

Susan is from the [Hospital X]. Nicola was explaining things to her, which provided me with an opportunity to learn.

Caroline, who was looking after patient 2, said how important the new beds were, and the new unit in general. Caroline qualified 15 years ago, worked at the ICU, went travelling and has been back for the past three years.

Jane has worked at the unit for a year, although was on sick-leave and maternity-leave for 6 months of that time. "And I don't know anything. I hate it. I'm going to leave but I haven't told them yet." (11:45 a.m.)

Joseph is an anaesthetist, probably in his late 20s. He is friendly and enthusiastic about what I am doing. James is a senior consultant, probably in his late 40s. He is helpful but slightly suspicious of what I am doing. Mike is a staff nurse and has worked in the ICU since 1993.

Mike (talking about the data they note hourly): "You can get computers to print it all out for you. I think it's good and bad, because you don't want to over-rely on it."

I moved back to patient 3 for a while. However, a decision had been made that she was not going to survive. Mike: "I don't think this is a good patient for you to watch". No more equipment would be added, but I felt I was being asked to moved because it would be inappropriate for me to watch.

The nurses move through very different tasks: comforting relatives, explaining the situation, some cleaning, adjusting equipment, cleaning patients.

Jane: “Magnesium, what’s that with?” Mike: “Its fine with salient.” Members of staff tell each other what they are going to do, help each other and ask for help.

The amount of attention given to a patient varies depending on their consciousness. If the patient is conscious, the nurse will talk to the patient, asking how they feel. If the patient is not conscious, members of staff still talk to the patient as they are moving the patient or checking the patient, referring to them by their first names. Apart from during ward rounds, attention focuses on data from the monitor. Nurses take the temperature of patients. The unit was quieter than I had expected.

At 12:15 – 12:45 p.m., there was the ward round, carried out by Caroline, Joan, James, and Joseph. Patient 2 has been in for five days. They looked at his skin and stomach size. All four were looking at the monitor and discussing. Caroline: “And I’ve written in my gases, even though Dr. Shetty didn’t write it in this morning.”

Caroline: “No news is good news.”

James: “No news is no news.”

There is a computer on the main desk with information from haematology and biochemistry, but Mike says that this often doesn’t work or says “system is busy” – time wasting “ornament”.

I had lunch in the staff room, which is shared with the anaesthetists. Some of the anaesthetists were talking about a new anaesthetic machine they were getting and the fact that there was going to be training. “It can’t be a very good anaesthetic machine if you need to be trained to use it first.” This new machine was being introduced because the alarm on the previous machine was too quiet.

Caroline and James set ventilator together, and say what they’re doing. They discuss the patient again, focusing on the monitor. Caroline (talking about vitamins and minerals): “One would presume they’d give him something there.” James: “Never presume. If we can get it wrong, so can they.”

I sometimes found it difficult to find an appropriate time to ask questions. It requires patience. I’m conscious of not asking too many questions now, until I have built up more trust.

The atmosphere changed throughout the day. The morning was busy because of unstable patient 3, whereas in the afternoon there were just two patients, who were both fairly stable. According to Nicola, the previous day had been very busy, with a patient who had

drunk a bottle of anti-freeze. “I thought my head was going to explode, with all the things I had to do, things to remember, functions, calculations.”

Nicola gave me a demonstration of the Aquarius system, an Automated Fluid Balance Monitor, made by Edwards. They purchased it 3 to 4 months ago and have had several versions of software because of problems. It rarely gets used (every 3 or 4 weeks) so they bring it out now and again so that staff can remind themselves how to use it. Joseph: “It’s the bane of my life, that machine.” The first few weeks, it kept alarming. Nicola: “That’s why the doctors hated it.” “We were continuously on the help line.” It only takes one person to set it up. There is a diagram of the machine on the screen but Nicola finds it difficult to relate the diagram to the machine. The buttons are meant to be universal but they aren’t. Nicola tells me what the buttons represent, although her descriptions are wrong. The operating manual is normally kept by the machine (black and white, 66 pages). The tubes sometimes get put in the wrong place. Nicola says that it is not as user-friendly as it was made out to be in the demonstration, which they were shown on a laptop. When the device first arrived, they were given a demonstration and then they each had a chance to have a go, with the first trained showing the others. Nicola says that it is easy to accidentally select the wrong option, and it can then be difficult to go back. The blood pump turns in reverse during Priming mode, which Nicola finds confusing. An older machine was lent to the [Hospital X] “overnight” and was returned this afternoon, three weeks later, which meant that the unit had no backup machine for 3 weeks. There is disagreement over how the Aquarius system works. According to Nicola, and confirmed by the person from the supplier, the Aquarius must be programmed at the bedside, whereas the old system could be moved. According to Joan (Nicola says), the new system can be moved. The level of information about equipment and the way that the machine was purchased seems to contrast with the multidisciplinary procurement approach I had been told about when I interviewed the sisters.

James gave me a demonstration of the Ward Watcher audit system (although I couldn’t help feeling that he was using this as an opportunity to suss me out, asking questions about what I was doing and checking that I had ethical approval). They have had the system since 1995, although it has been modified in that time to add new functionality, and they were either the third or fourth unit to receive the system. It is now used by all ICUs in Scotland, and the data is analysed by the Scottish Intensive Care Society. Data is entered for each patient on entry, 24 hours after arrival, and on departure. In analysing severity, data is taken from the hourly recordings (taken from the monitor and ventilator). It was

initially introduce to evaluate the APACHE III scoring system, although James says that there are other reasons, such as comparing ICUs. There is poor categorisation of diagnoses. There is a help system, which provides definitions of categories. They also have sections for TISS (Therapeutic Intervention Severity Scoring) and ACP, which allows them to identify trends. It is also used for staffing. There is a 'bed bureau' where it can be found which ICUs have spare beds. Previously, the Admission and Discharge Register was used to follow up the eventual outcomes of patients. James kept note cards for each patient. The register is now used as well. The new system is quicker but it creates extra tasks, according to James. Meetings are held to decide what will happen next with the system. The data is entered by consultants, although in other units it may be entered by more junior anaesthetists.

Staff from physiotherapy and pharmacy also came into the unit. Physiotherapy staff also make notes on patients using the data from the monitor and ventilator.

Nicola: "The night staff come in at quarter to 8 but sometimes I don't get away until 10 past 9."

Being in the unit is tiring because, even when I am taking a break in the staff room, I feel like I am working, either directly because people are talking about work and I am trying to remember what they are saying, or indirectly because I am trying to be liked and trusted. In this way, even though I am observing with permission and have declared my interests, I feel that there is a level of deception. When I am being friendly, it is a genuine friendliness but I cannot deny that my research needs further motivate me in the pursuit of such friendship. However, I was surprised at how quickly people shared personal information with me; in the dinner break, Nicola and Jane told me about their relationship history.

Nicola (talking about increased automation): "We're spoilt in some ways but it gives us time to do other things." Previously, trainee nurses would have spent a lot of time at the bedside. Now you can move around and, if you are watching a patient while another member of staff is on break, you can set your console to alarm for that patient.

According to Nicola, liquid from the patient can fall onto the electric socket extension, which is dangerous. They tried to have the syringe drivers plugged into sockets on the wall but the syringe drivers have standardised lead lengths.

A syringe driver started alarming. Caroline changed the syringe driver. It was then alarming again, with a message saying "ALARM VIOLATION" on the monitor. This was ignored and it stopped by itself after a couple of minutes. Nicola: "It's probably just

because of changing the syringe.” Soon after, another alarm for the same patient (patient 2) went off because his feed had ran out. Caroline recognised the sound of the alarm.

I got much more data today than I expected. I had decided to work three days in a row each week. I have now decided that it would be better to work Mondays, Wednesdays and Fridays, so that I have the following day to write up my notes; it seems more important to have good notes. I think I need to record times more. Today, I moved around a lot because I had people showing me different things. It would be good to stay in one place so that I can get a more accurate picture of how nurses spend their time. I also want to get clearer recordings of discussions that surround the equipment. I will look up more information about the equipment, scoring systems, the nursing “hierarchy” and the Scottish Intensive Care Society. I will also look at some more of the operating manuals.

Thursday 27th September (Day 2)

I arrive at 8a.m. I go and say hello to Lisa, who seems distracted. My experience of Lisa via the telephone is that she is very busy, with lots of meetings to attend. I then go onto the ward. There are 4 patients and patient 1 and patient 2 are the same patients that were here on Tuesday. On duty, there is the charge nurse, a supernumerary, a student, Lisa, a consultant, an anaesthetist and about 5 nurses.

Patient 3 was attached to a Gemini PC-2, two syringe drivers (these faced away from the bed, whereas patient 2 who I observed on day 1 had his syringe drivers facing the wall), a monitor and a ventilator.

Most of the staff on duty I hadn’t met before. William was the charge nurse and asked me about what I am doing. William seems to enjoy teaching, giving information to me, Susan and Becky. William suggested which patients I should watch.

I had to decide who to sit with: a choice between ‘average’ and ‘interesting’ patients.

For most of the day, I sat with patient 1, a renal patient, who was being looked after by Becky (a supernumary) and Caroline (a staff nurse). Susan was also observing. Patient 1 was attached to a ventilator, a Gemini PC-1 and PC-2, and a monitor. The monitor shows ECG, ART, CVP, SpO₂, and NIBP data. The CVP alarm was off. The drawers had been moved to the other side to make room for the Aquarius, which wasn’t attached.

On Tuesday, I had been unsure about sitting with patient 1 because she was awake. I told this to William: “The patient will tell you if she doesn’t like it.” The patients are used to being watched.

I told Caroline why I was there. Caroline: “Just don’t ask me to comment [on the equipment] because I might say bad things.” When the consultant David came over, Caroline said “She’s from Glasgow Uni. She’s looking at technical things.”

Becky has worked in the ICU for three weeks, having graduated this summer. She previously did a placement at [this hospital]. “I quite like our touch screens [on the monitors]. I was quite excited when I first came here.” “Have you been to [Hospital Y] in [city]? I think they have much older equipment there.” Becky had not seen a ventilator until she did her placement at [this hospital]. Learning about equipment was left to placements, although they did have one trip to a hospital to ‘play’ with the equipment. She says that intensive care tends to be much keener on continuing education than “general wards.” She finds it “frustrating when the patient is dopey and doesn’t want to do anything”.

Patient 1’s ART alarm went off quite often throughout the day (as expected by the staff). Ben said to Becky that you must always have a low alarm because otherwise you wouldn’t know if the monitor was disconnected. However, the high alarm goes when ‘flushing’. As the alarm is expected to go off when you do this, or in another case where you know a treatment will cause an alarm to go off, you can suspend the alarm for 45 seconds or three minutes. [The literature says that alarms often get ignored but this is with good reason.] Ben: “But I must qualify that by saying that I’m experienced. How significant do I think that is? I’d say it is very significant.” Alarms go off all the time but “we get paid to be annoyed.” However, it can worry patients, as they won’t know whether or not the alarm is for them. They may not even be aware that there are other patients there. Less experienced staff set narrower alarm limits. The ECG, CVP and SpO₂ all have high and low alarm settings. NIBP and ART have six alarm settings: median high and low, S high and low, and D high and low. Alarms are not going off all the time but they can come all at once. I find myself starting to recognise alarms but it can be difficult to tell which monitor the alarm is coming from.

Dialysis used to be done by the renal department but that was moved to the [Hospital Z], meaning that ICU staff had to learn to do dialysis (Caroline). First of all, they got a basic machine. They then tried a few more advanced machines and chose the Aquarius. They had quite a few cases where it was used during June. However, this was a busy time, so others were not able to watch. Therefore, there is a group of people who are practised in using it but none of them are in today. They were going to use the machine last night but they couldn’t work it. They could have telephoned the help line but they decided not to

because the patient had internal bleeding and they didn't want to worsen that. They were going to use the machine today but had decided not to. However, at 8:40 a.m., Caroline set up the Aquarius using the operating manual, for practice. At 9:10 a.m., Caroline drained the Aquarius, according to the system instructions, and fitted in the tubes, which she had difficulty with to get in. She also had difficulty selecting the right option first time. "I'm just practising." "Well, I must have done something right because it's working now." "Michaela, the rep, is coming in this afternoon so we can ask her some trouble shooting questions then." Caroline shook the central tube of the device. "When it's running, it's fine". The difficulty is setting up the device. When priming the device, at one point Caroline kept pressing the fourth button but this did nothing. An error message came up, which said "CPU arterial ... air detached" to which Caroline responded by looking around the device for possible sources of error. Eventually, the device was primed. Ben came over and Caroline said "I've primed it of a fashion." She said she would write down how she did it so that she had it in her own words. Caroline said that when priming, the Aquarius normally does all four 'wheels' (my description), but this time it missed one out and she didn't know why.

Staff from the physiotherapy department came in to take readings.

At 10 a.m., I went to the staff room for a break. Someone from another department said that one of their touch screen monitors wasn't letting them change the alarm settings, although it worked okay apart from that. She said that they had problems with that monitor before.

Staff spent sometime trying to identify patient 6.

At 10:45 a.m., I moved to patient 3, who had been in a car accident. Ben suggested this, because the nurse was setting up a PCA, which "takes up nurses' time". Patient 3 was awake. He had a button to press when he is sore. Joseph listened to his chest, using his hands and the stethoscope. The ventilator alarmed. Mandy: "It's my [drainage] chart. No one else will be able to understand it." She then explained her chart to Susan. Ben: "I think we're doing really well, guys. You can probably have a break soon." Joseph talked a lot to the patient. The patient asked to have a line taken out because it was sore. Joseph explained why that wasn't possible. I wait for a quieter time to look at the equipment. Ben mentions that he has checked the Bed Bureau. Patient 3 is demanding attention of members of staff, writing notes to them. The consultant, Mark, asks about what I am doing, how long I will be here, whether I will be going to other places, and offering help. I feel uncomfortable

with patient 3 when the staff go on a break, because I wouldn't know what to do if he wanted me to do something.

I move back to patient 1. Another nurse is reading through the Aquarius manual. It is a calm day. Becky cleans the patient's mouth and puts lip-salve on her lips for her.

There was a generator test sometime between 1 p.m. and 2 p.m. Staff were told to be prepared for manual operation of certain machines, although that shouldn't happen because they have an uninterruptible power supply. The ODM II doesn't have a battery backup.

At 12:30 p.m., I go for lunch in the staff room. I talk to James. He asks me more about my PhD. I ask him about what they did before they had the Bed Bureau. James: "The Bed Bureau's not the useful. I like phoning people." James says that it is not that much quicker because other hospitals would be able to tell you which other units were full. The Bed Bureau also relies on people updating it. James mentions the ICU at [Hospital W], saying that it is a "paperless" ICU and the only "paperless" ICU he knows of, because it requires good quality data. We talk about critical incident reporting systems. He compares the system in Australia with the system here, saying that in Australia they have separate people to analyse the data. James criticises the current focus on protocols, saying that it results in people just following the protocol, without understanding what they are doing.

At 1:30 p.m., the Aquarius representative arrives. Caroline explains the problems they have had with the machine but is unable to give any detail of what happened. Michaela: "I've no idea what was happening" so she is unable to give any suggestions. "Well, see what happens." "If you get a problem where the pre-dilution doesn't work, put it all post-dilution." Caroline: "It's just trying to understand what exactly it's [the manual] talking about." "...put it in my language." Michaela says that the problems they have had are "fairly standard", on the "checklist" of problems. The error messages "should tell you exactly what it is." Caroline asks for a longer cable so that they will be able to move the device.

Becky sets up the syringe driver but it alarms, with the message "Err 2". She and Caroline look at the base of the device. Becky goes to get another syringe driver. Caroline tries again (with the same device) and it's fine.

Becky explains to patient 3 why they have attached the Aquarius. "You know we said your kidney's not working as well as it should? Well, this machine is going to do the job of your kidney's for you." It is difficult to tell how the patient feels about the equipment because she is quite dopey.

At 2:15 p.m., visitors arrive to see patient 1, so I use it as an opportunity to look through some equipment manuals and the trust guide on the use and purchase of equipment. Ben says that it is fine for me to look through.

At 3:55 p.m., I go back to sitting with patient 1. Becky climbs over the wires from the monitor, which are a foot off the ground. The Aquarius alarms twice with the message: “high venous pressure”, although the message only comes up for a couple of seconds before disappearing again. Caroline gets the manual and tries different blood flow levels. She moves between the manual and the machine.

By 4:20 p.m., there are only two patients. Patient 2 has been taken to CT (computerised tomography) and patient 6 has discharged himself. Relaxing music is being played.

At 4:30 p.m., the Aquarius starts alarming again: “high venous pressure” and other messages. Caroline presses the fourth button a couple of times and then the third button.

At 4:55 p.m., patient 3 is brought back from CT.

Becky washes patient 1. Patient 1 looks at me and I tell Becky that she is looking distressed. I try to be of help by closing the curtain and passing Becky the patient’s notes.

At 5 p.m., while Caroline is helping Becky wash the patient, the Aquarius alarms again. Caroline is distracted, whereas Becky focuses on the patient, as the Aquarius has been Caroline’s responsibility. This time there is no message but the screen shows that there is high venous pressure. On around the 10th alarm, a message appears. Ben comes over and says that it looks like the blood is clotted.

Mandy says to Ben, talking about patient 3: “I could strangle that man.”

Ben: “We could all strangle that man.”

At 5:15 p.m., an alarm goes off and Becky looks around, unable to tell where the noise is coming from. The Aquarius comes up with the message “high venous pressure” again. Caroline keeps on pressing the fourth button but it doesn’t do anything. “Oh, for goodness sake.” Caroline looks at the machine, shaking her head. About ten times, the machine displays the message “venous pressure low”, followed by the alarm message “high venous pressure.” This is at variable intervals of around 10 seconds. Sometimes the alarm sounds but there is no message. There is then the message “balance system off”. Caroline is stretching to get a tube over the Aquarius. There is then the message “blood pump off, balance system off.” Caroline restarts the machine. Again, an alarm message comes up, saying “high venous pressure.” Caroline stops the dialysis and starts it again. “High arterial pressure.” Caroline is pressing the fourth button but nothing happens. She presses the third button but nothing happens. Caroline sighs. “Oh, would you just go” she says to the

machine. She doesn't ask for help from anyone. "I think we've lost it." Claire: "Is it gubbed?" Caroline: "I'm just trying to give her her blood back." At 5:35 p.m., Caroline gives up and closes the machine down. Rachel: "It's an evil machine, Mark. We said that a few months ago."

There is general amazement among the staff that I am working 8 a.m. until 8 p.m.

At dinner break, I go to the staff room, where I talk to Marcus, one of the consultants. "I remember when I started working in anaesthesia in the [Hospital Y] in [city] and we had blood pumps and 3 ECGs between 8 theatres, so if you were first in you'd get one." There is now an "over-reliance" on equipment, where if there is a problem, staff "forget to look at the patient".

Mandy, a staff nurse, asks about what I am doing. When I tell her, she says that "patients interfering with equipment" is a problem.

At 6:35 p.m., Caroline starts setting up the Aquarius. I try to work out how long it takes Caroline to set it up but it is difficult because she is swapping between different tasks. Caroline explains to Ben how she has set it up and explains what to do. When talking about unexpected behaviour of the machine, she says "for some reason" and "because it wasn't happy". Ben: "It looks quite impressive, doesn't it?"

Ben: "It's not really doing much, is it?"

Caroline: "It takes a wee while."

Caroline said that she had talked to the representative "just to iron out some problems that I had but I was happy after that." Caroline is visibly pleased at having managed to set up the Aquarius, smiling broadly. "I feel a lot happier now, more confident." "I feel quite chuffed now." Becky: "You have to learn the concept as well as the machine, not just the machine."

Ben: "And it's working fine now?"

Caroline: "At the moment."

Caroline, on the ACT: "I made a mess of that one."

Lisa comes to take over from Caroline and Becky for the night shift. Lisa, asking about how Caroline got the Aquarius working: "What did you do?" Caroline: "I don't know, I just took it all apart."

Caroline, giving her patient notes to Becky: "Its pretty shite actually." Becky: "Not as shite as mine."