Ethnography and Computer Science: Lessons From the Classroom

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Abstract

The Human-Computer Interaction (HCI) community has recently turned to a social science approach known as 'ethnography' for ways of understanding and explicating the social influences on computer use. Ethnography is a naturalistic approach to the investigation of human-computer interaction, which has gained particular prominence as a means of requirement gathering in the design of groupware systems.

This thesis argues that ethnographic studies are generating a narrow understanding of the social context of computer use, because they are generally based on an ethnomethodological understanding of social activity. Although ethnomethodological ethnography has provided valuable insights into the situated and collaborative nature of work in highly constrained settings, this thesis argues that the 'strong' version of ethnomethodology is inappropriate for the study of human-computer interaction in the complex organizational settings, in which most computer use takes place.

This thesis reports on an ethnographic study, which used a 'hybrid' methodology to investigate computer use in a complex organizational setting: the classroom. The hybrid methodology blended aspects of ethnomethodology with aspects of three other approaches to social activity; social constructivism, social worlds theory and grounded theory. Unlike other ethnographic studies, this study aimed to generate a theoretical account of computer use. It investigated patterns of activity across eleven different classrooms in four different primary schools in inner city Manchester.

Computer use in these classrooms failed to meet the expectations of educational technologists and National Curriculum legislators, despite exceptional levels of resources and support. Computers were not used for programming, database work or control work, but for copy-typing, basic practice exercises and adventure games. Furthermore, teachers retained control of the technology, and they gave some pupils more access to computers than others. This thesis argues that computers were used in unexpected ways because they were interpreted within the specific social, technical and physical circumstances which exist in classrooms. Moreover, computer use inside classrooms was also influenced by interpretations of computers outside classrooms.

This thesis explores the implications of this theory of classroom computer use for the concepts which constitute the discourse of HCI. It argues that concepts such as the 'user interface' and the 'user', dichotomies such as design/use and individual/social and assumptions about the nature of work do not stand up in the face of empirical evidence about what people do with computers in classrooms. This thesis argues that the concepts of HCI should be based more closely on an empirical understanding of the way people use computer systems.

Declaration

A small amount of data from one of the eleven classrooms used in this study (Mr Andrew's classroom at Range primary school) has already been submitted in support of an application for a Master's degree at the University of Manchester in 1992. This data is referred to on pages 135, 137, 148 and 164 of this thesis.

Copyright

About the Author

For the author, this thesis is the culmination of a long-standing interest in the boundary between the 'arts' and the 'sciences', the 'social' and the 'technical'. After taking both arts and science subjects at 'A' level, she studied for a BSc in Computational Linguistics and Modern Languages at UMIST between 1984 and 1988. It was during this time that she carried out her first study of technology and work practices; an investigation into the impact of machine aids on the work of translators.

In 1991, the author began studying for a Masters degree in Cognitive Science at the University of Manchester. There, she developed an interest in ethnographic techniques for human-computer interaction and first applied these techniques to the study of classrooms: she conducted a two month ethnographic study of computer use in a single primary classroom.

The research reported here grew out of this earlier study. The work was expanded to include new schools and classrooms, and the author focused her interest on the development of ethnographic techniques for the study of computer use in complex organizations.

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Dedication

To my mother Kate

my brother Sean

and my father Mike, who died on 13th January, 1984

Introduction

Since the field of Human-Computer Interaction (HCI) emerged in the early 1980s, it has focused on understanding the interactions between people and computer systems in terms of basic cognitive processes (e.g., Card, Moran and Newell, 1983; Norman, 1986). However, the cognitive view of human-computer interaction has recently come under criticism for failing to recognise the 'social' influences on computer use and, fuelled by a growing interest in Computer Supported Co-operative Work (CSCW), the field of HCI has begun to turn to the social sciences for ways of understanding and explicating these influences.

The 'turn to the social' in HCI has not taken the form of a turn to the social sciences in general. Rather, it has involved a turn to one approach in particular: ethnography. Ethnography is a naturalistic approach to the investigation of social activity, which involves detailed investigation of social phenomena using unobtrusive methods such as participant observation and interview (Atkinson and Hammersley, 1994). Ethnography has gained particular prominence in computer science as a means of requirement gathering in the design of CSCW systems. It is regarded as a way of uncovering 'what is really going on' in a setting by investigating 'natural' conditions in an 'unbiased' way (Somerville et al., 1992).

In computer science, ethnography is seen as a 'neutral' tool, which serves the enterprise of systems design. However, in the social sciences, it is a tool which serves theories of social activity. Each theoretical school uses a slightly different variant of ethnography tailored to its own goals. The particular variant of ethnography which serves the field of HCI is ethnomethodological ethnography (e.g., Heath and Luff, 1992; Hughes et al., 1992).

Ethnomethodological ethnography has dominated in HCI since Suchman (1987) used it as the basis of her influential study of photocopier use. This approach to ethnography has played a key role in the 'turn to the social', providing valuable insights into the situated and collaborative nature of human activity. This thesis argues, however, that it is time for a change of direction.

This thesis argues that ethnomethodology is generating a narrow understanding of the social context of human-computer interaction. Ethnomethodology's theoretical orientation to social activity influences all aspects of ethnomethodological studies, from the type of settings that researchers investigate (highly constrained), to the type of data they collect (observable action, particularly naturally occurring conversation) and the features of settings which they regard as significant ('ethnomethods'). In other words, ethnomethodological studies are generating an ethnomethodological understanding of human-computer interaction.

This thesis reports on an ethnographic study, which used a 'hybrid' methodology to investigate human-computer interaction. This hybrid methodology blended aspects of ethnomethodology (Garfinkel, 1967) with aspects of three other approaches to social activity; social constructivism (Pinch and Bijker, 1987), social worlds theory (Strauss, 1978) and grounded theory (Glaser and Strauss, 1967). All of these perspectives are problematic if applied to the study of human-computer interaction in a 'strong' form, so the hybrid methodology harnesses useful aspects of each perspective, while rejecting others.

The hybrid methodology takes its ontological assumptions from social constructivism: computer systems are said to be 'interpretively flexible'. That is, they may have different meanings for different people (Pinch and Bijker, 1987). This study aims to explicate the different meanings which become attached to computer systems. However, it also aims to relate these meanings to what people actually do with technology. It extends the concept of 'interpretive flexibility' to examine the actual acts and practices through which computer systems are interpreted. This emphasis on what people do with computer systems has its roots in an ethnomethodological understanding of human-computer interaction (Garfinkel, 1967; Button, 1993).

The hybrid methodology takes a sceptical approach to group and organizational boundaries. Groups and organizations are seen as fluid units with porous boundaries (Strauss, 1978). Hence, the study assumes that the way computer systems are perceived and used in one group may influence the way that they are perceived and used in other groups. The hybrid methodology also takes a sceptical approach to the concepts and dichotomies of human-computer interaction. Familiar concepts such as the 'user' and the 'computer', and dichotomies such that between the 'individual' and the 'social', are regarded as topics for empirical investigation.

Unlike other ethnographic studies, this study aims to generate a theoretical account of human-computer interaction. It aims to explain patterns of computer use using concepts and conceptual relationships which are grounded in ethnographic data. This commitment to theory generation is based in grounded theory (Glaser and Strauss, 1967).

This study aimed to generate a theory of computer use in a commonplace organizational setting: the classroom. It investigated patterns of computer use across eleven different classrooms in four primary schools in inner city Manchester. Almost all UK primary schools now have computers (DfE, 1993) and legislation exists to ensure that the technology is used in educationally effective ways (DfE, 1995). However, there is evidence to suggest that the technology is failing to deliver expected benefits (DfE, 1992; DfE, 1993). Other studies of classroom computer use (e.g., Cox, Rhodes and Hall, 1988; Watson, 1993) suggest that ineffective computer use is the result of inadequate resources, training and support. However, the schools in this study were among the best equipped in the country, due to their involvement in a unique government-funded scheme to raise educational standards through the use of technology.

This study asked broad questions about computer use in classrooms such as: why certain applications were used rather than others, when, where and how they were used. It found that computers were used in classrooms in unexpected ways. They were not used for LOGO programming, database work or control work. Rather, they were used for copy-typing, basic practice exercises and adventure games. Pupils did not have 'free' access to computers. Instead, teachers retained control of the technology. Moreover, teachers gave some pupils more access to the technology than others.

Computers were used in classrooms in unexpected ways, because they were interpreted within specific technical, physical and social circumstances. These circumstances included a hardware distribution of one computer per classroom, the 'closed' classroom organization of schooling and the social practices which evolved to manage computer activity within this setting. Moreover, interpretations of and interactions with computers inside classrooms were also influenced by interpretations of and interactions with computers outside classrooms.

This thesis explores the implications of this theory of classroom computer use for the concepts which constitute the discourse of HCI. It argues that concepts such as the 'user interface' and the 'user', dichotomies such as that between the 'individual' and the 'social' and assumptions about the nature of 'work' are untenable in the face of empirical evidence about what people do with computers in classrooms. Furthermore, this study argues that users re-design computer systems in use. Design is not a process which ends in the laboratory. It is a process which continues during the implementation and use of computer systems.

This thesis is divided into five main chapters. The first chapter examines different approaches in the field of HCI to people's interactions with computers. The second chapter describes a hybrid methodology for the study of human-computer interaction, which blends aspects of four different approaches to social activity. Chapter three describes the study of classroom computer use which was carried out using this hybrid methodology, while Chapter four describes the theory of classroom computer use which resulted from the study. The final chapter assesses the implications of this theory for the concepts and dichotomies which constitute the discourse of HCI.

Chapter 1: Perspectives on human-computer interaction

Introduction

This chapter considers different approaches in the field of human-computer interaction (HCI) to people's interactions with computers. The term human-computer interaction is used here in a broad sense to include work done in the area of Computer-supported Co-operative Work (CSCW), which is usually treated as a field in its own right. Since the field of HCI emerged in the early 1980's, it has been dominated by approaches, which understand the interactions between people and computer systems in terms of basic cognitive processes. However, in recent years the cognitive perspective has come under criticism for failing to take account of the social influences on computer use, and the field of HCI has begun to turn to the social sciences for ways of explicating and understanding these influences.

It is this 'turn to the social' which is the focus of the following review. This chapter examines the direction that the turn to the social sciences is taking and asks whether the field of HCI should follow a different course in the future. However, the chapter begins with a brief examination of the perspective which has dominated the field for most of its history; cognitivism.

Cognitivism

Since its emergence in the early 1980's, the field of HCI has focused on understanding the interactions between people and computer systems in terms of basic cognitive processes. Cognitive scientists have argued that people, like computers, can be viewed as information-processing devices composed of memories, processors and parameters (e.g., Card, Moran and Newell, 1983; Norman, 1986). The model of human-computer interaction proposed by Card, Moran and Newell (1983) has been particularly influential. They argued that information-processing psychology provided an ideal foundation for a science of human-computer interaction, since it allowed computer scientists to conceptualize users in their own terms and would therefore encourage greater consideration of user issues in design. Moreover, they claimed that a science of human-computer interaction had to be based on calculation and prediction, since "the ability to do calculations is at the heart of useful, engineering-oriented applied science" (Card, Moran and Newell, 1983: 10).

The model proposed by Card and colleagues (ibid.) facilitates the calculation and prediction of performance by describing the human-computer system in terms of a limited number of elements. According to their model, the human-computer system consists of the user, the computer and the task. They define the user's knowledge of the computer system in terms of Goals, Operators, Methods and Selection (GOMS) rules. This GOMS model is based on the principle that users act rationally in order to attain goals. Users achieve goals by breaking them down into a series of smaller operations or subgoals. If this sequence of operations can be specified, then user behaviour can be predicted. Card, Moran and Newell (ibid.) propose that the user's goals and subgoals are specified through task analysis. They argue that the *task* is the key to understanding user behaviour, since it is the task which determines users' goals.

Task analysis based on the GOMS model has achieved considerable popularity among HCI practitioners. The original method proposed by Card, Moran and Newell (ibid.) now exists in a number of different forms (e.g., Kieras, 1988). The appeal of this method lies in its claim to predict important aspects of the usability of software interfaces without the need for 'costly' user testing. Design alternatives can be evaluated using scenarios in a laboratory (Gong and Kieras, 1994). However, information-processing models such as GOMS hold other advantages for HCI. By describing users in purely cognitive terms, they have the potential to deliver general design principles, which are applicable across different applications and user groups. For example, Card, Moran and Newell (1983) formulated a set of general 'user interface design principles' based on their GOMS model.

Despite the obvious appeal of the cognitive view of human-computer interaction, it has recently been the subject of criticism both within the computer sciences and from other disciplines, most notably the social sciences. The field of human-computer interaction is taking what is widely referred to as 'a turn to the social' (Anderson et al., 1993; Bannon, 1994). This shift in perspective constitutes two different, but related, elements (Anderson et al., 1993). On the one hand, there is an increasing awareness that the use of computer systems is influenced by a wide range of 'social' factors hitherto unrecognised in 'cognitive' explanations of human-computer interaction. Secondly, and in direct response to this growing awareness, HCI practitioners and systems designers are turning to the social sciences for ways of explicating and understanding these social influences. The next section considers the first element of this 'turn to the social'; the growing awareness that the use of computer systems is influenced by 'social' factors, which are unrecognised in 'cognitive' accounts of human-computer interaction.

Challenges to cognitivism

Challenges to the cognitive view of human-computer interaction have come from both theoretical and empirical sources within the computer sciences and the social sciences. In the computer sciences, the theoretical work of Winograd and Flores (1987) has popularised an anti-cognitive perspective. They argue that it is impossible to predict user behaviour on the basis of a set of goals and operators, since the model of the user as a rational actor is fundamentally flawed. Drawing on Austin and Searle's work on Speech Act Theory and the philosophical writings of Heidegger, they argue that people's interactions with computers should be considered as "cognition as praxis". That is, they argue that our ability to act is not in the cognitive representation but "in the doing" and that to understand how people interact with computers we need to understand the context of use.

Adding to this theoretical criticism is a growing recognition among computer scientists that many systems fail to deliver expected benefits because of a sociotechnical 'mismatch'; that is, a mismatch between the functionality of the system as conceived by designers and the social context of use (Grudin, 1991). Somerville and colleagues (1992) argue that most current systems have significant usability problems, which result from a failure to consider the sociality of work in design, while Quintas (1993) cites the example of the US Department of Defence, which has usability problems with almost 99% of the software that it receives. Many of the problems are so acute that almost half the software received by the Department is never used at all. There is also a growing awareness that users adapt and alter software which is insensitive to the social context of use, with the result that systems are often used in ways which were not anticipated during design (Winograd and Flores, 1987).

Empirical research in the social sciences has fuelled criticism of the cognitive view of human-computer interaction and has begun to explicate some of the social factors which affect computer use. Suchman's (1987) empirical study[1] of photocopier use has been particularly influential. Suchman (ibid.) demonstrated clearly that models such as GOMS, which presume rational action on the part of users, do no justice to the complex manner in which people deal with routine problems such as photocopier breakdown. She argued that people's actions are 'situated' in particular, concrete circumstances and cannot be fully described in terms of cognitive constructs such as goals and operators. Suchman's (ibid.) work was a key critique of the 'strong' cognitive program in HCI. By demonstrating that actions are context-sensitive, she cast doubt on cognitive accounts of human-computer interaction and inspired studies of situated action in other settings (e.g., Heath and Luff, 1992; Hughes et al., 1992).[2]

Empirical studies of computer use have also cast doubt on the efficacy of the terms and concepts which constitute the discourse of HCI. The field of HCI constructed a number of concepts such as the 'user' and the 'user interface' as part of its attempts to achieve disciplinary status (Cooper and Bowers, 1995). The sense of these terms is largely taken for granted. In fact, their meanings are so 'obvious' that they rarely merit any explicit clarification in HCI texts. The 'user interface' is understood as the site of interaction between the 'user' (described in cognitive terms) and the computer. It is seen as a discrete and tangible entity, comprising the screen and its design. However, Grudin (1990) argues that this conception of the interface simply reflects the current state of computer technology, while Bowers and Rodden (1993) claim

[1]Suchman's (1987) methodology will be discussed in detail in later sections of this chapter.

[2]These studies will be discussed more fully in the next section of this chapter.

that it is untenable as a description of real world interactions with computer systems. Their study of a computer network identified many different 'interfaces' of importance to users. They argue that a more useful concept of the interface could be achieved by exploring how users themselves orient to computer systems, what they treat as the 'interface' and where they see the locus of interaction.

Similarly, Anderson et al. (1993) question commonly held assumptions about the boundaries of the 'human-computer system'. While recognising the predictive power of formal models such as GOMS (Card, Moran and Newell, 1983), Anderson and colleagues (1993) argue that such models are inadequate as a description of what people actually do with computers. Cognitive theories like GOMS define the boundaries of the human-computer system in terms of the computer, the cognitive system of the user and the 'interface' between them. However, Anderson et al. (ibid.) argue that once the social dimensions of human-computer interaction are considered, the human-computer system has no 'natural' boundaries. Rather, it is a *boundless* system. Winograd and Flores (1987) make a similar point. They argue that the properties of entities like the 'human-computer system' and the 'interface' are generated in the discourse of those who build and discuss them. They see a need to re-examine these concepts within a situated understanding of human-computer interaction, which considers computer use in its social context.

Interest in the social context of computer use has been fuelled by the emergence of the field of Computer-supported Co-operative Work (CSCW), which focuses on the development of multi-user or 'groupware' systems (Randall, Hughes and Shapiro, 1993).[3] CSCW

[3]This is a grossly over-simplified characterisation of a highly contested and disputed field, whose complexites are discussed in Bannon (1994), Grudin (1991) and Hughes et al. (1991).

practitioners argue that while it might be possible to overlook the social context of use in the design of single-user applications, the design of co-operative systems requires a more sophisticated understanding of the social nature of work and new techniques for deriving system requirements. For example, Grudin (1991) argues that while the social aspects of computer use can generally be ignored in the design of a word processing application or programming language, they are important considerations in the design of 'groupware'. Many practitioners argue that while laboratory based methods are capable of obtaining findings about individual behaviour, they are ill-suited to measuring or observing *social* action (e.g., Monk et al. 1993).

The growth of interest in CSCW systems has fostered new approaches to system development and the study of social interaction. In design, there has been a move towards user involvement with renewed interest in techniques like participatory design (Kyng, 1994) and Sociotechnical design (Mumford, 1987), and in the study of human-computer interaction, there has been a move away from laboratory experiments towards investigation of 'real world' settings. Approaches like activity theory and contextual inquiry are part of this trend. Activity theory (Bannon and Bodker, 1991) is a theoretical approach which emphasizes that artefacts acquire meaning through their incorporation into social practices. In contrast, contextual inquiry (Whiteside et al., 1988) is a practical approach developed at Digital Equipment Corporation to support product development. It comprises a set of 'discount' field research techniques, which aim to explicate users' work practices for the purpose of informing design.

Distributed cognition (e.g., Hutchins, 1991; Hutchins and Klausen, 1992) is another approach which focuses on the study of activity in real world settings. However, unlike other naturalistic approaches, distributed cognition does not replace a cognitive analysis of activity with a social analysis. Instead, it examines cognition in its social context. Distributed cognition analyses how complex tasks are distributed among systems, composed of individuals, technological artefacts and other tools. This approach has been used to analyse complex activities such as ship navigation (Hutchins, 1991) and the flying of aircraft (Hutchins and Klausen, 1992).

The approaches described above are part of a growing body of work, which challenges the idea that human-computer interaction can be described in purely cognitive terms. The field of HCI has begun to recognise the 'social' influences on computer use and, fuelled by a growing interest in CSCW systems, it is turning to new ways of understanding and explicating these influences. An important part of this 'turn to the social' is the current interest in social science approaches to activity.

The social sciences have a tradition in the study of social phenomena, and it is natural that the computer sciences should turn in this direction for the tools to explicate the social influences on computer use. However, borrowing methods from one discipline to serve another is problematic: methods are developed to serve specific goals and theories, which may be incompatible with those of other disciplines. The following section examines the use of social science methods within the computer sciences, and it considers the problems of integrating these methods into the design process.

Ethnography

The 'turn to the social' in the computer sciences has not taken the form of a turn to the social sciences in general. Rather, it has involved a turn to one approach in particular; ethnography. The term 'ethnography' has a number of different senses, which will be discussed shortly. However, it is generally used to describe detailed investigations of social phenomena in naturally occurring settings, usually involving a period of participant observation, during which the ethnographer gathers data using unobtrusive methods such as observation and interview (Atkinson and Hammersley, 1994).

Ethnography has its origins in the work of social and cultural anthropologists in the late nineteenth and early twentieth centuries (ibid.). It was around this time that anthropologists began to study the customs and rituals of isolated societies through close and long term contact with their members, having previously relied on the second-hand tales of travellers and missionaries (Hammersley, 1992). Ethnography therefore developed as a reaction against the 'inaccuracies' of second-hand accounts, and it has a strong emphasis on gathering data through extended participant observation in order to understand phenomena "from an insider's perspective" (ibid.).

'Ethnography' has achieved prominence in the computer sciences as a means of explicating the complexity of interaction in co-operative work settings (Shapiro, 1994). The relevance of this approach for CSCW was first brought to light by Suchman's (1987) study of 'situated' action. This study was not only an important critique of the 'strong' cognitive programme in HCI, it also emphasized the co-operative and context-specific nature of work, and raised awareness that the development of multi-user systems would require a method of accessing the specific character of co-operative work in 'real world' settings. Suchman (1987) demonstrated clearly that the laboratory-based techniques common to HCI could not hope to capture adequately the requirements of co-operative systems, because they were insensitive to the context-specific nature of activity. She argued that an empirical approach was needed, which did not presuppose the relevant conditions of activity, but captured as much of its 'real world' context as possible. She proposed that 'ethnographic' methods developed by social scientists to study 'real world' activity were more appropriate.

In recent years, ethnographic techniques have been used to investigate a number of different co-operative work settings. The settings include a London Underground line control room (Heath and Luff, 1992), offices (Suchman 1983, Suchman and Wynn 1984), a city dealing room (Heath et al. 1993) and Air Traffic Control (Hughes, Randall and Shapiro, 1992). The studies all aimed to explicate the complexities of work practices in the setting, with a view to informing the design of appropriate technologies. For example, Heath and Luff (1992) found that London Underground line controllers work in extremely close collaboration, which is achieved by surreptitious monitoring of colleagues' work, the organization of activities so as to render them 'publicly visible' and mutual access to information displays. Heath and Luff (ibid.) found that technologies introduced into this environment were "shaped, corrupted, even abandoned" in order to preserve the public availability of information, which allows controllers to co-ordinate their activities.

Heath and colleagues (1993) went on to investigate share trading in a dealing room in the City of London, where they made similar observations about the close collaboration between dealers and the way that collaboration is achieved. Dealers, like London Underground controllers, are able to monitor each others activities whilst engaged in other relatively distinct tasks. They achieve this by attending to gross, visible features of co-workers' conduct such as the completion of a telephone conversation or the writing of a 'ticket' (which signals the closing of a deal). Hughes and colleagues (1992) found that the work of air traffic controllers also involved close teamwork and 'peripheral' monitoring of co-workers' actions. Planes were 'handed over' from one controller to another without explicit communication, an achievement made possible by the use of public documents called 'flight strips', on which controllers record the history of an aircraft's passage through a sector.

The studies described above are based on interviews, transcripts of conversation and observation. However, Suchman's studies of office work are slightly different in that they are based solely on transcripts of conversation (Suchman, 1983) and interviews (Suchman and Wynn, 1984). These studies emphasize that office activity is grounded not only in the social organization of the setting, but also in its physical and material organization. For example, Suchman and Wynn (1984) found that documents had a directionality in the office which was oriented to and represented materially in the organization of personal workspace. They also found, for instance, that spatial proximity facilitated collaboration between co-workers.

Although these ethnographic studies have generated valuable insights into the collaborative nature of work and the ways that collaboration is achieved, they have had little impact on the actual design of systems. Only one of these studies (Hughes, Randall and Shapiro, 1992) was carried out with the explicit objective of informing the design of a system. As Hughes and colleagues (1992) observe, the alliance between ethnography and systems design is currently more a research agenda than a set of established practices.

The problems of integrating ethnography into systems design have received considerable attention. In fact, in most discussions of ethnography (e.g., Hughes, Randall and Shapiro, 1992; Somerville et al. 1992; Randall & Bentley, 1992; Hughes et al. 1994), the problems associated with the approach receive at least as much attention as the benefits. The problem which receives most attention is the difficulty of translating ethnographic data into system requirements. Hughes, Randall and Shapiro (1992: 75) observe that "the rich, highly detailed, highly textured, but nevertheless partial and selective descriptions associated with ethnography would seem to contribute little to resolving the designer's problem where the objective is to determine what should be designed and how".

Somerville and colleagues (1992) attribute the mismatch between ethnographic data and the design process to the different approaches of ethnographers and computer scientists: computer scientists have a solution-focused agenda and use information to make design decisions, while ethnographers generate detailed descriptions of social phenomena and are reluctant to draw conclusions. Somerville et al. (1992) also remark on the lack of a theoretical framework for deriving system requirements from ethnographic observations. This forced them to adopt a pragmatic approach in their project to develop a system for Air Traffic Control. They held a series of debriefing meetings, in which ethnographers informed designers about significant aspects of the setting and designers then directed ethnographers to issues of significance for design.

There are a couple of trends in these discussions of ethnography which are worth noting in the context of the 'turn to the social'. Firstly, despite the attention given to the problems associated with ethnography, it's status as *the* sociological tool of choice is never called into question. Ethnography is not discussed as one of a number of social science approaches which could inform HCI and systems design. It is treated as *the* social science approach. Secondly, the nature of ethnography and its defining characteristics are rarely considered problematic. Ethnography is treated as a homogeneous approach, which needs little explication. However, for the social scientists who engage in ethnographic studies of workplace settings, ethnography is less a definitive approach than an umbrella term, denoting little more than an alternative to quantitative approaches and a commitment to a period of immersion in the setting studied (Shapiro 1994).

In the social sciences, ethnography is a method which serves a whole range of theoretical schools including Marxism, structuralism and symbolic interactionism (Atkinson and Hammersley, 1994). Each theoretical school is as focused in its aims as systems design and each uses a slightly different variant of ethnography tailored to its own goals. For example, symbolic interactionist ethnography aims to explicate the different ways in which people perceive their circumstances (Cuff, Sharrock and Francis, 1990), while Marxist ethnography focuses on uncovering forms of societal oppression (Kincheloe and McLaren, 1994). In the social sciences, it makes little sense to consider ethnography as a 'method' independent of the theoretical orientation to which it is committed. Yet in the computer sciences it is often treated in precisely this manner.

The use of ethnography in design is commonly justified on the basis of its 'neutrality'. Experimental methods are said to run the risk of overlooking significant variables by investigating assumed hypotheses under artificial conditions, while ethnography investigates 'natural' conditions in an unbiased way. Ethnography is regarded as a way of uncovering 'what is really going on' in a setting.[4] For example,

[4]This discussion is continued in the next chapter in relation to other possible understandings of ethnography.

Somerville and colleagues (1992: 344) argue that "sociologists have extensive experience in studying societies in an objective way without prejudices as to what they might discover ... unlike technologists, they do not approach the study with preconceived notions of the application systems which might be developed".

Although it is a reasonable assumption that sociologists will not approach an ethnographic study with preconceptions about the *systems* which might later be developed, it is inevitable that they will approach the study with preconceptions about the nature of social activity, and that the methods they deploy will reflect these preconceptions. Sociologists work within and are informed by particular schools of thought concerning the nature of society, and they deploy methods which serve the goals of these schools. In the computer sciences, ethnography is seen as a tool serving the enterprise of systems design. In the social sciences, it is a tool which serves theories about society and social activity.

The particular variant of ethnography which currently informs HCI and systems design is more correctly known as *ethnomethodological ethnography*; ethnography carried out under the auspices of a theoretical school in the social sciences known as ethnomethodology. While it is not true to say that all ethnographies of human-computer interaction are strictly ethnomethodological, this approach to ethnography has dominated the field of HCI since Suchman (1987) used it as the basis of her influential study of 'situated' action.[5] Suchman's study was not only an important critique of the 'strong' cognitive programme in HCI. It also demonstrated the relevance of ethnomethodological ethnography as a means of explicating the co-operative character of work, at a time when interest in CSCW systems

[5]Other approaches to ethnography will be discussed in the next chapter.

was growing (Randall, Hughes and Shapiro, 1993). Following Suchman's lead, other ethnomethodologists turned their attention to co-operative work settings. The studies described earlier by Heath and Luff (1992, Heath et al., 1993) and Hughes, Randall and Shapiro (1992) all adopt an ethnomethodological approach, as do other studies by Suchman (1983, Suchman and Wynn 1984). These studies furthered understanding of the socially organised character of work and encouraged the current interest in ethnomethodological ethnography.

The precise nature of ethnomethodology's theoretical orientation will be discussed shortly. It is enough to note here that ethnographic studies of workplace settings have a theoretical orientation which influences all aspects of the studies. For the focus of these studies is not human-computer interaction, but social activity.[6] As Button (1993) notes in the introduction to his collection of ethnomethodological studies:

> It is important to stress that all of the studies are *sociological studies* [original emphasis] and are primarily involved in developing descriptions of the ordering of the work of technology for sociologists. Thus the studies are concerned with making points that, hopefully, sociologists will find interesting.

What is remarkable, then, is that HCI and systems design have given such little attention to the theoretical basis of ethnography or to the implications of its sociological agenda. This is not to say that the problems of interdisciplinarity have been ignored altogether. As stated earlier, the problems of using ethnography in systems design have received considerable attention. What is at issue here is the nature of that attention. As Shapiro (1994: 418) observes, "it has become a shorthand or simplification ... to speak of ethnography when in fact

[6]Sociologists' current interest in human-computer interaction parallels that shown earlier by cognitive psychologists, whose ultimate focus was not human-computer interaction, but cognition. For example, Card, Moran and Newell (1983: 3) state "our goal is to create an applied information-processing psychology ... as with all applied science, this can only be done by working with some specific domain of application. For us, this domain is the human-computer interface."

what is involved is ethnomethodological ethnography". Ethnography is discussed as a homogenous and 'neutral' approach, which is able to get to the bottom of 'what is really going on' in a setting. Hence, questions are raised about the difficulty of utilising ethnographic data in the design process (e.g., Somerville et al., 1992; Randall and Bentley, 1992; Hughes et al., 1994), but no questions are raised about the data per se. There are problems in deciding *what to do with* ethnographic data, but there are no problems *with* ethnographic data. The difficulty of using ethnographic data in the design process is said to have its roots in the divergent aims and traditions of sociology and computer science. However, no consideration is given to the possible implications of these different aims and traditions for the aspects of real world settings which ethnography reveals as significant or for the understanding of social context which it generates.

Ethnomethodological ethnography has played a key role in 'the turn to the social' in the computer sciences. Following Suchman's (1987) lead, it has been instrumental in raising awareness of the 'situated' and collaborative nature of human activity and it remains at the forefront of attempts to understand the social context of computer use. However, there has been little critical evaluation of this approach within the computer sciences. There has been little consideration of whether the goals of ethnomethodology are compatible with those of the computer sciences or of the implications of ethnomethodological goals for the settings that ethnomethodologists choose to investigate, the methods that they have developed to investigate them and the understanding of social context that they generate. The next section considers these questions. It recovers the ethnomethodology in ethnography and it reassess the ethnographic studies discussed earlier in the light of this theoretical orientation.

Ethnomethodological ethnography

Ethnomethodological ethnography takes as its starting point a framework originally developed by Harold Garfinkel (1967). Garfinkel developed this framework to investigate a question which has motivated much of sociology: how is social order possible? However, Garfinkel's approach is radically different to that of mainstream sociology. While most theories claim that we enact social order on the basis of a set of underlying cognitive rules, Garfinkel claims that orderliness in the social world is the practical accomplishment of the members of the sociocultural group that live in it. That is, the social world is not something that is objective and 'out there'. For Garfinkel, the sense of objective reality which exists in the social world is created by members themselves through everyday acts and practices.

The idea that people create social order is the key idea of ethnomethodology, and the investigation of how they do it is its goal (Cuff, Sharrock and Francis, 1990). According to Garfinkel (1967), social order is produced in and through 'ethnomethods'. Ethnomethods are said to be present in observable action, particularly conversation. Through conversation, people are continually engaged in recognizing and making recognizable to each other the orderliness of the social world: in describing, referring to and naming events, people give sense to them and persuade others of their sense (O'Keefe, 1979).

This theoretical orientation has implications for the aims and methods of ethnomethodological studies of human-computer interaction. Ethnomethodology is an empirical program, which recommends detailed investigation of naturally occurring settings in order to identify the everyday acts and practices through which members organize and manage those settings. Randall, Hughes and Shapiro

(1993) claim that this attention to the detail of naturally occurring settings makes ethnomethodology an ideal method for computer science. They argue that the fundamental problem for systems design, particularly in the context of CSCW, is to build up detailed empirical descriptions of working practices in real world settings and that ethnomethodological studies can make a significant contribution. However, ethnomethodology's orientation to the problem of social order has consequences for the nature of the descriptions that are generated.

Although ethnography is regarded in the computer sciences as an unbiased method which has the potential to uncover 'what's really going on' (Somerville et al., 1992), ethnomethodology's theoretical orientation accords certain aspects of a setting more significance than others at the outset. The aim of these studies is not to specify significant aspects of the setting *in general* or aspects of particular significance for human-computer interaction, but to specify the methods used by members to produce a sense of social order within a setting, their 'ethnomethods'. Shapiro (1994: 419) observes that this agenda "is equivalent to instructing the researcher to describe those and only those aspects of the setting which can be used to demonstrate its self-ordering properties; and to organize the description such that it emphasises those properties".

However, ethnomethodology is even more specific in its instructions to researchers: the ethnomethods to be identified consist of overt, observable actions. For Garfinkel, social order is not generated by a set of cognitive processes which underlie action, but by the character of action itself (O'Keefe, 1979). Hence, everything of significance in a setting is public and observable. Conversation is considered to be of particular significance, because it is through this interaction that members produce, recognize and make recognizable to each other the orderliness of the setting.[7] As Shapiro (1994: 419) observes, ethnomethodology specifies "not only how to look but also what to find".

What ethnomethodological studies find is illustrated by the studies discussed earlier (Heath and Luff, 1992; Heath et al., 1993; Hughes, Randall and Shapiro, 1992; Suchman, 1987; Suchman, 1983; Suchman and Wynn, 1984). They find that actions are 'situated' in particular social and physical circumstances: according to the ethnomethodological view, it is the interpretation of these actions in context (rather than a set of underlying cognitive rules) which creates and sustains shared understanding and a sense of social order (O'Keefe, 1979). The studies also emphasize the collaborative nature of work and the means by which collaboration is achieved; that is, the ways in which information is recognized and made recognizable as 'publicly available'. Ethnomethodological studies (e.g., Heath and Luff, 1992; Hughes, Randall and Shapiro, 1992; Suchman, 1987) have generated findings of great importance to the field of HCI, and it is not my intention to undermine their contribution. However, it is clear that there is a relationship between the aspects of human-computer interaction which these studies reveal as significant and the perspective which informs them. It should be no surprise that studies based on the premise that actions are 'situated' in a publicly available and collaboratively organized world reveal precisely that.

Ethnomethodology's recommendations as to what to find also has implications for where to look. Since ethnomethodology focuses on

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[7]This emphasis on conversation is particularly developed in a branch of ethnomethodology known as conversation analysis, which attempts to describe and explicate the collaborative practices used by speakers when they engage in ordinary conversation (eg. Sacks, Schegloff and Jefferson, 1978).

detailed interaction, particularly conversation, studies tend to be carried out in settings with small numbers of participants which are conducive to this type of micro-interactional focus. Hence, Suchman (1987) studied users of a photocopier machine, Hughes, Randall and Shapiro (1992) studied the interactions of a group of air traffic controllers and Heath and Luff (1992) investigated activity among the controllers in a London Underground line control room. Heath et al. (1993) also investigated work in a city dealing room. However, they maintained a narrow focus by concentrating on the interactions of two dealers at a single desk in the room. While these studies have been instrumental in demonstrating the 'situated' and collaborative nature of activity, they are nonetheless studies of specific systems in highly constrained settings, which are in many ways unrepresentative of the complex organizational settings in which the vast majority of computer use takes place.

It is not only ethnomethodology's focus on small groups of people in highly constrained settings which could arguably lead to a narrow understanding of the social context of computer use. Although computers are now used in many different settings for a wide range of purposes including education and entertainment, ethnomethodology focuses solely on the use of computers for 'work'. This focus has historical roots. Ethnomethodological studies of technology developed from a branch of ethnomethodology concerned with explicating work practices (Button, 1993). Since work settings are populated by people of working age, these studies generate an understanding of computer use by people within a particular age range. They do not consider the social context of computer use in settings where the users are older adults or children.

Although ethnomethodological studies (e.g., Heath and Luff, 1992; Hughes et al., 1992) focus exclusively on 'work' settings, they rarely examine the meaning of work in those settings (Nyce and Lowgren, 1995). These studies generate detailed observations of work processes, but give little consideration to what work is; that is, to what 'counts' as work, how work differs from other types of activity or how the appearance of work is produced and recognised. As Nyce and Lowgren (1995) observe, the category of 'work' is of fundamental importance to systems design. Yet ethnomethodological studies of human-computer interaction take the meaning of this category as self-evident.

Many ethnomethodological studies of work have been carried out in control rooms (e.g., Heath and Luff, 1992; Hughes, Randall and Shapiro, 1992). The control room is an ideal setting for an ethnomethodological study. Not only does this social world constitute a small number of members whose interaction can be examined in detail, members also form an easily identifiable 'group' which is engaged in close collaboration. Moreover, control rooms tend to be 'closed' environments with relatively well-defined boundaries. For example, in the London Underground line control room studied by Heath and Luff (1992), two controllers usually worked together as a team, occasionally joined by a third person. Although this team also communicated with people outside the control room, the 2 or 3 people inside the control room are the 'team' whose interaction forms the focus of the study.

However, few settings are easily defined in terms of small social groups with stable boundaries. Indeed, even the controllers in Heath and Luff's (ibid.) study were engaged in interactions beyond the physical confines of the control room with signal men, train drivers and other workers within London Underground. The goals of ethnomethodology require that settings are defined so as to facilitate the specification of detailed interactions within a small group of people. Yet there is no guarantee that these pre-defined boundaries represent the 'natural' dimensions of the social context of computer use. Strauss (1978) argues, for example, that groups and organizations have fluid and fuzzy boundaries. They do not exist in isolation. Rather, they interact with other groups and organizations in multiple 'social worlds'.[8] Strauss (ibid.) therefore argues that formal representations of group and organizational boundaries should be treated as problematic and subjected to empirical investigation.

Most computer use takes place in complex organizations composed of many different groups, which themselves exist in an even larger arena in which they interact with other organizations. Yet ethnomethodology focuses on the study of highly-constrained settings, whose boundaries are defined in terms of a single social world. It tells us little about the dimensions and boundaries of the wider organizational context of computer use. Furthermore, it is not clear that interactions in the wider organizational context have the same 'public', observable character as those in highly constrained settings or will yield to the same methods of investigation.

One aspect of ethnomethodology's orientation to social activity which has been recognised as problematic for the Computer Sciences is its anti-theoretical stance (e.g., Shapiro, 1994). Ethnomethodologists argue that theory distorts "the actual day to day social life of human beings" (Mehan and Wood, 1975). They argue that the process of abstraction conceals people's experience of everyday life, transforming "a real human situation into a collection of logical categories" (ibid.). Ethnomethodologists therefore aim to follow a strict discipline of observation and description, rather than causal explanation (Holstein

[8]Strauss's theory of 'social worlds' is discussed in detail in the next chapter.

and Gubrium, 1994). There is some dispute as to whether or not ethnomethodology actually succeeds in these endeavours (Shapiro, 1994). Nonetheless, description rather than explanation is its goal.

Ethnomethodology's descriptive programme is problematic for a solution-focused enterprise such as systems design, which requires engineers to make decisions based on data. If ethnomethodology is to inform design, it needs some way of reaching conclusions and making design recommendations (Shapiro, 1994). Shapiro (ibid.: 421) argues that this currently takes the form of 'covert theorising', in which studies are "sometimes concluded with a discussion of design implications, but these are typically reticent". Since theorising is not supposed to take place, it cannot be acknowledged. Hughes et al. (1994) also argue that there is a need for a corpus of ethnographic studies, which emphasizes generic features of the social organization of activity in 'real world' settings. However, the 'strong' programme of ethnomethodology currently rules out such generalization.

Shapiro (1994) suggests that the difficulties associated with the 'strong' programme of ethnomethodology could be overcome by developing 'hybrid forms', which 'satisfice' for the purposes of system design. He argues that there is no point in treating ethnomethodology as a "hermetically sealed endeavour". Instead, he recommends that the results of ethnomethodological studies are recruited for more 'conventional' theorising. This is one solution to the problem of using ethnographic data in systems design. However, it could be argued that a more radical departure is necessary. Recruiting the results of ethnomethodological studies for theorising will help solve the dilemma about *what to do with* ethnographic data. Yet a more fundamental problem remains.

Ethnomethodological studies have generated valuable insights into the 'situated' character of collaborative work practices in particular types of settings. However, continuing the current ethnomethodological course in the 'turn to the social' runs a couple of risks. Firstly, the techniques which serve its micro-interactional focus may not prove as successful for investigations of the more complex organizational settings, in which the vast majority of computer use takes place. However, of more fundamental concern is the possibility that significant dimensions of the social context of computer use could be overlooked altogether.

Ethnomethodological studies are generating an ethnomethodological understanding of the social context of computer use. Ethnomethodology is a theory about the nature of social order. Its research practices are designed to further this theory, to explicate members' 'ethnomethods'. The dimensions of human-computer interaction revealed by these investigative practices are those which ethnomethodology deems significant. As this thesis demonstrates, there is more to the social context of computer use than is revealed by ethnomethodology.

Goguen (1993: 136) argues that a theory which aims to serve the computer sciences should "support practical action rather than try to explicate the nature of reality". He (ibid.: 136) therefore sees no reason to "adhere rigidly to any particular theoretical stance" and he draws on other sociological approaches in addition to ethnomethodology. This study adopts a similar approach to the investigation of human-computer interaction. An investigation of human-computer interaction should aim to explicate multiple dimensions of the phenomenon. This hybrid approach therefore draws on other sociological perspectives in addition to ethnomethodology. The next chapter describes this hybrid approach.

Chapter 2: A synthetic approach to the study of human-computer interaction

Introduction

This chapter describes a 'synthetic' or 'hybrid' approach to the study of human-computer interaction in complex organizations. The approach blends four different sociological perspectives: grounded theory, social constructivism, social worlds theory and ethnomethodology.[9] Each of the perspectives deploys a version of ethnography in its inquiries and each of the perspectives is problematic if applied to the study of human-computer interaction in a 'strong' form. Indeed, the problems of ethnomethodology's anti-theoretical agenda and narrow focus were emphasized in the previous chapter. This synthetic approach therefore blends aspects of all four perspectives. Although the perspectives are based on contradictory assumptions and are not obviously compatible, I will argue that if some aspects of the perspectives are harnessed while others are rejected, the result is a hybrid with greater potential than any of the 'pure' approaches.

The remainder of this chapter describes the hybrid approach which evolved from critical evaluation of the perspectives mentioned. In describing this process, the impression will no doubt be given that the relevance of the perspectives was established and a methodology finalised before any research began. Of course, this is not the case. The relevance of the approaches, the problems associated with them and the

[9]Sociological 'perspectives' are understood here as distinctive ways of trying to understand the social world, each with their own aims, assumptions and methods (Cuff, Sharrock and Francis, 1990). However, grounded theory is less a perspective than a methodology; it is a way of thinking about data rather than a way of thinking about social order (although it is based on certain assumptions about the nature of the world).

possibilities for synthesis emerged to a great extent during the research process itself.

Combining perspectives

In the previous chapter, I argued that the 'strong' programme of ethnomethodology was unsuitable for investigating human-computer interaction in complex organizations and that the computer sciences would be better served by blending ethnomethodological ethnography with other sociological approaches. However, sociological methods cannot simply be 'mixed and matched' as if they were 'neutral' tools. Methods are bound up with the perspectives which they serve. They embody fundamental beliefs about the world, what there is to know and how it can be known (Guba and Lincoln, 1994).

The previous chapter examined ethnomethodology's beliefs about the world and the methods it deploys to investigate those beliefs. According to the ethnomethodological view, social order is created through everyday acts and practices, or 'ethnomethods'. Ethnomethodologists aim to explicate 'ethnomethods', which are said to be present in observable action, particularly conversation, and they deploy methods developed for this specific purpose. Grounded theory, social constructivism and social worlds theory are based on different worldviews, and their aims and methods are in many ways incompatible. At first glance, it is difficult to see how the perspectives could be fused. In the social sciences, theoretical perspectives are usually rejected wholesale, not blended with alternate perspectives into new forms (ibid.). Sociologists might argue against the development of such 'hybrids'. However, the interest here is human-computer interaction, and it is in this interest that the perspectives are blended.

In order to blend these apparently contradictory perspectives in a coherent manner, the fundamental assumptions of each approach are laid bare, before explicit choices are made about which assumptions to adopt in the new hybrid and which to reject. In explicating the assumptions of each perspective, three fundamental issues are addressed: ontology, epistemology and methodology. That is, I consider how each perspective views reality (and what can be known about it), how it understands the relationship between the researcher and what can be known, and how it goes about finding what it believes can be known (Guba and Lincoln, 1994). At each stage, I make clear where the new approach stands in relation to these issues. The importance of making these assumptions explicit will become evident later in the chapter.

In order to develop a new approach, it is essential to be clear about what is required. The previous chapter concluded that ethnomethodology was inadequate for investigating human-computer interaction in complex organizations because of its anti-theoretical agenda and narrow focus. To reiterate the recommendations of that chapter, the new hybrid should have a 'broad' focus. That is, it should aim to explicate multiple 'social' dimensions of human-computer interaction, rather than ethnomethods. It should consider all data as potentially significant and should not privilege observable action and conversation. Furthermore, it should be appropriate for investigating complex organizational settings and it should treat the boundaries of those settings as topics for empirical study. The approach should also be theoretical rather than descriptive in its aim. That is, it should aim to generate a theoretical formulation, which consists of concepts and conceptual relationships and which allows conclusions to be drawn and recommendations to be made. The next section considers the potential contribution of one approach which has an explicit commitment to generating theory.

Grounded Theory

Grounded theory is "a methodology for developing theory that is grounded in data, systematically gathered and analysed" (Strauss and Corbin, 1994). Unlike ethnomethodology and many other approaches, grounded theory is committed to generating theory. It was introduced by Glaser and Strauss (1967) over 25 years ago at a time when much qualitative research was considered to be too impressionistic and 'woolly'. Glaser and Strauss (ibid.) attempted to give qualitative research some of the 'rigour' associated with quantitative techniques by developing a 'systematic set of procedures', designed to meet the criteria of 'good' science.

Grounded theory's emphasis on theory generation is based in a commitment to develop a useful product. Strauss and Corbin (1994) argue that theory is essential to 'scientific' understanding: without theory, there can be no testable propositions and no cumulative knowledge. Moreover, they argue that social research should be of practical as well as theoretical value. It should not only benefit social scientists, but also the people that they study. Glaser and Strauss (1967) emphasized this commitment to informing practice when they laid out the principles of their method in 'The Discovery of Grounded Theory'. They stated that a grounded theory should comprise 'meaningfully relevant' concepts and relationships, which are understandable to practitioners and which allow control over action.

When Glaser and Strauss (1967) introduced grounded theory, they argued that most sociological theories were of limited practical use.

Theories were derived by logical deduction rather than empirical research, and Glaser and Strauss (ibid.) argued that many simply did not fit the phenomena that they were supposed to explain, because they were insufficiently grounded in actual data. They argued that theory should be inductively derived through interplay with data gathered in the field. They recommended that investigations begin with a general question rather than a specific hypothesis. Hence, a grounded theory study initially considers all data relevant.[10] The research only narrows and becomes more focused in later stages, once some concepts and relationships are discovered to be relevant and others irrelevant.

Data collection in grounded theory shares many similarities with other forms of qualitative research (Strauss and Corbin, 1994). Data are generally collected using ethnographic techniques such as participant observation and interview. When Glaser and Strauss (1967: 66) introduced the method, they offered little advice about data collection, except to recommend that there be "no limits to the techniques of data collection, the way they are used or the types of data acquired". They suggested that variety in the techniques and sources of data collection would improve the emerging theory. The distinctive feature of data collection in grounded theory is its relationship to data analysis. The two operations take place concurrently, and as the study progresses data collection is increasingly influenced by the emerging theory. Glaser and Strauss (1967: 58) stress that grounded theorists are "active samplers of theoretically relevant data", who should go where the next theoretical question takes them. They even recommend that (ibid.: 59) "if ongoing events do not give [the researcher] theoretical relevance, he must be prepared to manipulate events by words or actions in order to see what will happen".

[10]This assertion implies that the investigator carries no prior assumptions into the field and is able to treat all data as truly equivalent. This view of research will be discussed in more depth later.

Although data collection in grounded theory has much in common with other modes of ethnographic research, data analysis is quite distinctive. Data are coded according to a complex scheme, which involves three different types of coding: open, axial and selective coding (Strauss and Corbin, 1990). These operations occur at different stages of the research process. The first stage is open coding, which involves comparative analysis of incidents and events. Similar incidents and events are grouped and labelled to form categories. Axial coding is a more focused process. Categories are developed, and hypotheses are formulated and validated against data. In the final process of selective coding, a single 'core' category is selected and its relationship to other subsidiary categories is established and verified. The verification of categories and their relationships against data is said to 'ground' the emerging theory. The final product of this coding process is a theoretical formulation, in which subsidiary categories are arranged around a single core category in a tree structure. Categories become increasingly abstract towards the core of the structure, while peripheral categories remain closer to actual data. All categories are related to the core category and to each other by explicit causal links.

Grounded theory's coding procedure has obvious potential to meet the requirement outlined earlier for the hybrid to generate findings which can be applied. Whereas ethnomethodology's descriptive agenda does not allow conclusions to be drawn or recommendations to be made, grounded theory aims to generate findings which 'work' in practice. Moreover, it has the additional goal of producing findings which will contribute to a cumulative knowledge base. Grounded theory aims to achieve both goals by generating theory. That is, it abstracts from the detail of field data to generate concepts and conceptual relationships, which are said to constitute an explanation of the phenomena under investigation (Strauss and Corbin, 1990). In other words, grounded theory represents a potential solution to the dilemma about *what to do with* ethnographic data.

Grounded theory also offers a solution to the problem of ethnographic data itself. In the previous chapter, I claimed that ethnomethodological ethnographies generate a narrow understanding of human-computer interaction in 'real world' settings, because they are driven by an ethnomethodological agenda. That is, they aim to explicate just those features of a setting which demonstrate its self-ordering properties (Shapiro, 1994). In contrast, I argued that investigations of human-computer interaction should aim to explicate the features of a setting which are significant for understanding people's interactions with computers. While ethnomethodological investigations aim to uncover ethnomethods, grounded theory has no such commitment.[11] Instead, it aims to generate a theory which 'fits' the phenomenon in question. While ethnomethodologists' primary source of data is naturally occurring conversation, grounded theorists consider all data potentially relevant, and researchers are encouraged to sample different types of data in a wide range of conditions in order to generate as comprehensive a theory as possible (ibid.).

Grounded theory's inductive approach to investigation meets the requirements of the hybrid methodology. In order to develop a comprehensive understanding of human-computer interaction in 'real world' settings, few assumptions should be made prior to investigation about which aspects of a setting are relevant to understanding the phenomenon. This understanding should be allowed to emerge during investigation, although it will be informed at the outset by certain ideas

[11]This is not to say that grounded theory has no commitment to a particular view of the world. This view will be discussed shortly.

about human-computer interaction, which may or may not prove relevant (the ideas which informed this study are discussed in the following sections of this chapter). This inductive aspect of grounded theory's investigative strategy is therefore carried forward in the hybrid, although it will be qualified later in a discussion of epistemology. However, grounded theory's commitment to develop theory is not quite as straightforward as it first seemed, and this principle must be qualified before it can be adopted: the problem is grounded theory's understanding of what is meant by 'theory'.

Grounded theory aims to generate theory which 'works' in practice (Strauss and Corbin, 1990). Glaser and Strauss (1967) claim that grounded theories 'work' because they have the power of prediction. They make this claim on the basis that grounded theories constitute causal explanations of the phenomena that they represent. This understanding of 'theory' is very similar to the traditional sociological view, represented in an introductory textbook by Brinkerhoff and White (1991). Brinkerhoff and White (1991: 30) define 'theory' as "an interrelated set of assumptions that explains observed patterns". The term 'explain' has the sense of 'causal' explanation. That is, theory constitutes a set of cause-effect relationships between variables, which account for a particular situation or phenomenon. From these cause-effect relationships, predictions can be made about the effects of intervening to alter variables in particular ways. Traditionally in sociology, these hypothesized relationships have been derived by logical deduction, then tested empirically (ibid.). In grounded theory, hypotheses are both generated and tested empirically (Glaser and Strauss, 1967). However, in both cases, the aim is the same; to generate explanatory theory, which predicts the effects of intervening in social phenomena.

The idea that grounded theories constitute causal explanations with predictive power is very promising for the field of HCI, where the value of theories with predictive power has long been recognised (e.g., Carroll and Olson, 1988; Kieras, 1988). Therein lies the appeal of cognitive theories of human-computer interaction. The problem is that theories which claim predictive power are associated with a view of the research process and of reality to which few sociologists now subscribe.

A realist ontology and objectivist epistemology

When Glaser and Strauss (1967) introduced their method, they claimed that grounded theories were faithful representations of reality. Or at least, as faithful a representation as could be achieved, given that reality is never perfectly apprehendable. Nevertheless, reality is assumed to exist and objectivity is the aim. Hence, the method's emphasis on 'grounding' theories through the verification of hypotheses against data. Strauss and Corbin (1990: 26) argue that if grounded theory procedures are followed properly, the resulting theory is "an accurate representation of reality".

The claim that grounded theories 'represent reality' has been widely criticised in the context of recent ontological and epistemological arguments in the social sciences. This claim has associations with a paradigm[12] which used to guide most social science research, but is now almost universally rejected (Guba and Lincoln, 1994). The positivist paradigm is based on the belief that there is an external reality, which can be investigated in an objective manner to generate findings which constitute a 'true' or 'factual' explanation of events

[12]The term 'paradigm' denotes a basic belief system or 'worldview', which guides researchers in questions of ontology, epistemology and method (Guba and Lincoln, 1994).

(ibid.). Investigators working in this tradition tend to carry out experimental research, in which previously derived hypotheses are verified and stringent measures are followed to prevent the influence of researcher bias on findings. However, the assumptions which guide this mode of inquiry have recently been challenged.

Philosophers of science now argue that facts are not ultimately 'true', but only recognisable as 'facts' within a particular theoretical framework. That is, what comes to count as 'fact' is shaped by the theory which informs an investigation. Moreover, philosophers also argue that the same set of 'facts' can support any number of different theories (Zimmerman, 1988). In other words, 'facts' are socially constructed: what comes to count as 'fact' is not determined purely by empirical evidence, but by other 'social' influences. Work in the sociology of science has begun to investigate these influences. For example, Knorr-Cetina (1981) and Latour and Woolgar (1979) demonstrate how scientific 'facts' are constructed through the everyday activities of work in biological laboratories. Both studies emphasize that 'facts' are not just the outcome of laboratory experiments. Rather, they are the outcome of collective activity in specific circumstances.

The argument that scientific 'facts' are socially constructed has undermined the notion of objective inquiry and the idea that 'science' can uncover the 'real truth'. Most social scientists now reject the idea that research findings constitute an objective representation of things 'as they really are' and instead regard findings as the product of interaction between researcher and research phenomenon.[13] For example, Guba (1990: 26) argues that "the results of an inquiry are always shaped by the interaction of inquirer and inquired into ... it makes the findings of an inquiry not a report of what is "out there" but

[13]This argument will be developed later in the chapter.

the residue of a process that literally creates them". In response to challenges to positivism, alternative research paradigms have emerged in the social sciences. Grounded theory (Glaser and Strauss, 1967) belongs to one of these alternative paradigms; postpositivism.

Postpositivism is essentially a 'modified' version of positivism. Unlike other alternative paradigms, postpositivism does not respond to criticisms of positivism by replacing positivist assumptions with a radically different belief system. Instead, postpositivism retains positivist assumptions in a diluted form (Guba, 1990). Ontologically, postpositivism moves from a position of naive realism to critical realism. Hence, grounded theorists (Glaser and Strauss, 1967; Strauss and Corbin, 1990) argue that although reality exists, it is only imperfectly apprehendable, and findings are regarded as probably rather than absolutely 'true'. Epistemologically, postpositivism recognises that objectivity is difficult to achieve in practice, although it retains the principle as a research ideal. Hence, grounded theorists (e.g., ibid.) attempt to identify and eliminate biases in their research. Methodologically, there is an emphasis on 'discovering' theory, and hypotheses are generated during rather than prior to research. Investigations are also conducted in 'natural' rather than experimental settings. However, postpositivist inquires have the same aims as positivist research; to explain, predict and allow control over social phenomena (Strauss and Corbin, 1990). Moreover, postpositivist research uses equivalent criteria to judge investigations. Grounded theory retains positivist criteria, but in a slightly altered form.

In the positivist paradigm, inquiries are judged according to four basic criteria: the degree to which findings correctly map the phenomenon in question, the degree to which findings can be generalized to similar settings, the extent to which findings can be reproduced by another inquirer and the extent to which findings are free from bias (Guba and Lincoln, 1994). These criteria are based on the assumption that an external reality exists, which can be investigated in an objective manner. When Glaser and Strauss (1967) introduced grounded theory, they argued that the 'canons of good science' should be retained in a form which better suits the reality of qualitative research. That is, they argue that criteria should reflect the difficulty of capturing reality and achieving objectivity in practice. For example, the canon of reproducibility is retained in the following form (Strauss and Corbin, 1990: 251):

> Given the same theoretical perspective of the original researcher and following the same general rules for data gathering and analysis, plus a similar set of conditions, another investigator should be able to come up with the same theoretical explanation about the given phenomenon. Whatever discrepancies that arise can be worked out through reexamination of the data and identification of the different conditions that may be operating in each case.

In other words, grounded theorists argue that although it is possible to replicate findings, it is difficult to achieve in practice. They also argue that findings are generalizable to a limited extent in that "if elsewhere approximately similar conditions obtain, then approximately similar consequences should occur" (Strauss and Corbin, 1994: 278).

In order to meet the canons of 'good science', grounded theorists conduct their research according to the systematic procedures and complex coding schemes mentioned earlier. However, social scientists working in other research traditions argue that these procedures are based on fundamentally flawed assumptions (Denzin, 1994). For example, researchers working within the constructivist paradigm argue that there is no external reality to be apprehended even imperfectly. They argue that "realities are multiple and they exist in people's minds" (Guba, 1990: 26). Constructivists do not regard these mental constructions as 'true' in any absolute sense: truth is relative.

(Schwandt, 1994). Hence, constructivists have different aims and methods. The goal is not to predict or control social phenomena, but to identify the range of constructions which exist, and methods aim to explicate these constructions.

Postmodernism has also challenged the assumptions of positivism and postpositivism in recent years and is currently influential in the social sciences. Postmodernism is not a distinct research paradigm, but a general intellectual movement, which is difficult to define. In the words of Skrtic (1990: 127), "postmodernism is a relatively vague conception". It constitutes a number of different strands, but is particularly associated with the philosophical writings of Foucault (1980), and Derrida (1982). Foucault (ibid.) is concerned with the nature of knowledge and its relationship to power, while Derrida (ibid.) focuses on the nature of language and writing. Both philosophers challenge the postpositivist assumption that the 'truth' can be uncovered through objective inquiry. Foucault (ibid.) emphasizes how politics and values, rather than objective epistemology, determine 'truth', while Derrida (ibid.) argues that 'truth' is not present in written texts, but in the reading and writing of them.

The influence of these arguments is manifested in the social sciences as a concern for the way that ethnographic inquiries are conducted and presented. 'Postmodern' ethnographers (e.g., Denzin, 1994; Clifford, 1990) regard the findings of ethnographic inquiry as value-mediated: findings are said to be literally 'created' through interaction between the researcher and the researched, and they are inextricably linked to the values of both parties (Guba and Lincoln, 1994). Researchers self-consciously reflect on their values and their interactions with research participants in an attempt to assess their influence on findings (Vidich and Stanford, 1994). Self-conscious reflection is also the hallmark of postmodern ethnographic texts.

Whereas grounded theorists present findings as 'factual' (Strauss and Corbin, 1990), postmodern ethnographers are moving away from a position of textual authority. They employ a variety of devices to alert the reader to the possibility of multiple interpretations (Marcus, 1994). These 'reflexive' texts take different forms. Some ethnographers convey the uncertainty of inquiry by writing 'confessional' accounts, which provide the 'inside story' on fieldwork in a relatively conventional textual style (e.g., Cooper et al. 1995). Others break textual conventions by experimenting with new literary forms, which emphasize the text's own textuality. For example, in multivoiced or dialogical texts (e.g., Woolgar, 1991; Wynne, 1988), different 'voices' are used to convey information which is often lost in conventional texts, such as the remarks of research participants or the second thoughts of the writer. However, reflexivity is not a panacea solution to the 'problem' of textual authority, as the next section of this chapter reveals.

Postmodern ethnography is not only characterized by distinctive methods and forms of textual representation. It also has different goals and criteria of 'goodness'. The aim is not to 'explain' social phenomena by establishing generalizations, because meaning and activity are said to be located in particular, localized circumstances about which no generalizations can be made (Vidich and Stanford, 1994). Researchers therefore aim to generate 'thick descriptions', which preserve the multiple understandings of research participants and the particular, localized context of meaning.

Some postmodern ethnographers adopt the additional aim of 'transformation' in their inquiries. That is, they aim to actually transform the lives of those whom they study (Kincheloe and McLaren, 1994). However, this goal is not to be confused with the type of control sought by positivist inquiries. While positivist research aims to achieve control through objective explanation of 'the way things really are', objectivity has no role in postmodern inquiry. On the contrary, researchers often adopt an explicitly partisan approach. Informed by perspectives such as feminism and Marxism, these studies aim to resist forms of 'oppression'. For example, Griffin (1985) investigates the effects of patriarchy on the experiences of adolescent girls, while Willis (1977) examines the effects of class on the educational and working lives of 'working class' children.

Ethnographers influenced by postmodernism and constructivism argue that since findings are value-mediated, they cannot usefully be judged against the traditional 'scientific' canons (Denzin, 1994). They reject canons such as generalizability and reliability in favour of alternative criteria. For example, Kincheloe and McLaren (1994) suggest a canon of 'trustworthiness', which is judged against factors such as the plausibility of findings to research participants, while Guba and Lincoln (1994) propose the canon of 'authenticity', which includes the degree to which findings provoke and empower action. Although these alternative criteria mark a useful distinction with positivist canons, their proponents admit that they provide little basis for actually evaluating findings and that the issue of quality criteria is far from resolved.

To summarize, critics of grounded theory argue that it is too closely aligned with positivism. They argue that although postpositivism represents an improvement on classical positivism, it nevertheless "fails to make a clean break" (Guba and Lincoln, 1994: 116). Grounded theory does not accept that findings are inevitably value-mediated. Instead, it retains the canon of objectivity. It maintains that an external reality exists, although it concedes that it is difficult to apprehend. Grounded theory's ontological and epistemological claims are difficult to uphold in the light of the powerful counterarguments of constructivists and postmodernists. Nevertheless, grounded theory principles have appeal. Grounded theory's explicit commitment to generating theory offers a way out of HCI's dilemma about what to do with ethnographic data. Furthermore, the principle of inductive theory generation, in which all data is initially considered relevant, meets the need for broad exploration of the dimensions of human-computer interaction.

One solution to this dilemma lies in accepting some of the basic principles of grounded theory, while rejecting the approach's ontological and epistemological assumptions. At first glance, this solution appears intractable. I have already argued that methods cannot be considered 'neutral'. They are designed to investigate particular types of worlds, about which particular things can be known. Questions of method follow questions of ontology and epistemology (Guba and Lincoln, 1994). Nevertheless, I will argue that grounded theory can be modified in this way: it can be done by reconsidering what is meant by 'theory'. The next section of this chapter modifies Glaser and Strauss's (1967) understanding of 'theory' in the light of recent ontological and epistemological arguments, while the following section assesses whether the resulting methodology still retains recognisable elements of grounded theory.

A modification of grounded theory

I have justified the development of a hybrid methodology by arguing that in the interests of the field of HCI, it might be necessary to develop methodologies which would be considered inappropriate in the social sciences. However, the potential of a modified grounded theory approach is recognised within the social sciences (Denzin, 1994). This appreciation of grounded theory principles is based in a growing recognition that all ethnographic accounts embody theories. Even accounts informed by 'anti-theoretical' perspectives, such as ethnomethodology, embody theories. Denzin (1994) argues that ethnographic accounts embody theories because they are interpretations. He (ibid.: 500) observes that "in the social sciences there is only interpretation. Nothing speaks for itself." He (ibid.: 500) continues:

> ... interpretation requires the telling of a story, or a narrative that states "things happen this way because" or "this happened, after this happened, because this happened first". Interpreters as story tellers tell narrative tales with beginnings, middles and ends. These tales always embody implicit and explicit theories of causality, where narrative or textual causality is presumed to map the actual goings-on in the real world.

In order to 'have something to say', ethnomethodologists and other ethnographers interpret beyond what is found in data (Shapiro, 1994). They give explanations which are not actually provided by data, effecting "some kind of transition to concepts, categories and arguments" (ibid.: 419).

There is another argument to support the claim that all ethnographic accounts embody theories; the argument that no data is theory neutral. This argument was introduced in the previous chapter with the claim that ethnomethodological ethnography generates a narrow understanding of the phenomenon of human-computer interaction, because it instructs researchers to focus on specific features of a setting (ethnomethods) by collecting specific types of data (observable interaction, particularly naturally occurring conversation). In other words, there is a direct relationship between the data generated by an approach and the understanding (or 'theory') of social activity which informs it. Even 'anti-theoretical' approaches like ethnomethodological ethnography are based on theories, which shape the understanding of human-computer interaction that they generate.

Reflexivity is one response to the 'problem' of implicit theories in ethnographic accounts. As discussed in the previous section, postmodern ethnographers use a variety of devices to dissuade readers from interpreting the theories embodied in ethnographic accounts as 'factual'. However, reflexivity is not a solution to the problems of textual representation. Fujimura (1991) argues that ethnographers 'hide behind' reflexive devices. That is, they use them to deny their responsibilities as analysts. She observes that "none of us can avoid making an interpretation, even at a descriptive level" (ibid.: 231). She claims, however, that reflexive devices are used to do just that. This point is also taken up by Denzin (1994), Pinch (1988), Latour (1988) and Collins and Yearley (1992). They each recognise that reflexive devices such as multivocality create the impression that voices are given equal consideration when, in fact, the analyst always remains firmly in control.

Latour (1988) also argues that some ethnographers see reflexivity as a way of creating texts which are 'better' than other forms of text. That is, they see reflexivity as a way of creating texts which are "somehow more than just another story" (ibid.: 171). Latour (ibid.) argues that all forms of textual representation are 'stories', and that no amount of reflexivity will ever turn accounts into anything more. He argues that explanations are also stories, including those explanations which claim to be 'scientific' (ibid.). Latour observes, "no explanation, no matter how abstract the science, no matter how powerful the regime, has ever consisted of anything more than a disproportionate amount of heterogeneous, historical, contingent elements" (ibid.: 163). On this basis, Latour argues that researchers can reject objectivity and the existence of an external reality, but still offer explanations. He proposes that they offer 'non-scientific and weaker' explanations, which use self-exemplifying principles of analysis and ask no privilege for their accounts.

Fujimura (1991) draws on Latour's (ibid.) argument to suggest that grounded theories can be viewed as a 'weaker' form of explanation. Like Latour, she argues that social inquiry can reject the notions of objectivity and 'absolute truth', but can still offer explanations.[14] She states (Fujimura, 1991: 218):

> While we will never be able *fully* [original emphasis] to understand and represent the views of the other, this does not mean that we should not even attempt to "explain" science. Woolgar argues that we should refrain from constructing explanations of science and society in order to avoid naive realism.[15] But there are explanations and there are "explanations". While I do not disagree with Woolgar on fundamental assumptions about the nature of knowledge or representations, I strongly disagree with him about the possibility of representing knowledge construction and its consequences.

In other words, grounded theories can be viewed as 'explanations' rather than explanations; as representations which embody explicit theories of causality, but which make no claim to represent 'reality',

[14]Although Fujimura (ibid.) and Latour (1988) agree about the possibility of generating 'explanations', they disagree about how and why they should be generated. Latour is equally interested in humans and non-humans, giving both 'actor' status, while Fujimura's theories are driven by an interest in people and what they do. Moreover, Latour (ibid.) constructs networks of associations between heterogeneous elements, while Fujimura (1991) constructs concepts and theories.

[15]Woolgar (1988) argues that ethnographers should refrain from constructing explanations which attempt to persuade the reader of a particular interpretation of events. Instead, they should offer 'reflexive' accounts, which make explicit the possibility of alternative interpretations.

because they are informed by a perspective which makes different assumptions about the world and what can be known about it.

Retaining a commitment to generate theory, even theory which does not claim to represent 'reality', has a number of advantages. Firstly, it is possible to draw conclusions and make recommendations. It is possible to construct persuasive arguments, which attempt to convince an audience about a particular interpretation of events, and which prepare against the possibility of not being believed; an outcome which Latour (1988) and Fujimura (1991) argue is far more likely than the reflexivists' fear of being believed too much. Moreover, if Latour's (ibid.) view of 'explanation' is adopted, there is no reason to regard these theories as any less 'scientific' than those constructed using the methods of the 'hard' sciences.

There is another important reason for retaining a commitment to grounded theory principles: grounded theory compels analysts to take responsibility for their own interpretations (Strauss and Corbin, 1990). All ethnographic accounts are interpretations (Denzin, 1994; Hammersley and Atkinson, 1990; Fujimura, 1991). They all embody theories of causality. Yet if theories are 'hidden', so are the processes by which they were derived. If theories are not supposed to exist, the reader is provided with little basis on which to judge them. Glaser and Strauss (1967) argue that it is essential to be explicit about how theories are derived, so that readers can assess their quality and usefulness. They argue that it is impossible to divorce the quality of a theory from the process by which it was generated.

Of course, grounded theorists (Glaser and Strauss, 1967; Strauss and Corbin, 1990) also argue that theories should be judged against the 'canons of good science'. That is, they should be judged against criteria such as objectivity and reproducibility. These criteria are obviously inappropriate in the context of the new hybrid, given that I have already rejected the ontological and epistemological assumptions on which they are based. However, it is appropriate to take responsibility for an interpretation and to specify explicitly how it was generated. In the words of Fujimura (1991:237) "when I write ... I must take responsibility and hold myself accountable for the final perspective. The point is to make explicit to myself and to my audiences just where I stand, my operating perspective, and the grounds on which my concepts are constructed". If readers are informed about how theories are generated, they have the tools to make their own judgements about 'quality'. There is no need to appeal to the 'canons of good science'. A well constructed and persuasive theory will stand, while an unconvincing theory will fall.

In the light of the previous discussion, the idea of 'theory' has been amended to mean the following. Theory consists of concepts and conceptual relationships, which are 'grounded' in field data. Theory is 'grounded' in the sense that it is based on patterns observed in data. Theory generation is inductive in that hypotheses are derived from data and all data is initially considered relevant. However, the investigation is guided by a prior understanding of human-computer interaction, which is described later in this chapter. Theory is 'local' rather than 'universal' in the sense that generalizations are based on observations of human-computer interaction in the particular, localized circumstances described in the next chapter. Theory is 'causal' in that it attempts to 'explain' human-computer interaction; to show what makes computer use as it is in a real world setting. However, this does not necessarily mean that theory has strong predictive power: it is not an accurate representation of 'reality', but one interpretation of events. Moreover, it may be that the nature of human-computer interaction in complex organizations is such that even if cause-effect relationships are established, it is impossible to predict the effects of particular interventions with any certainty. This issue will be discussed in a later chapter.

What remains of 'grounded theory'?

In the last section, fundamental ontological and epistemological assumptions of grounded theory were rejected. Theories no longer represent reality but a particular interpretation of events. They no longer appeal to 'the canons of good science'. Instead, they stand or fall on the reader's assessment of the way they are presented and generated. This raises the question of whether the new hybrid actually resembles grounded theory at all or whether, by rejecting these assumptions, the method's central features have been lost.

Since its introduction over 25 years ago, grounded theory has been applied to a diverse range of phenomena by researchers working in a broad range of disciplines (Strauss and Corbin, 1994). These include education (e.g., Nias, 1989), organizational culture (e.g., Sackmann, 1991, Yeager and Cram, 1990) and the sociology of science (e.g., Fujimura, 1987; Star, 1989). Researchers have taken different approaches to grounded theory depending on their interests, experience and circumstances. Some (e.g., Sackmann, 1991) have followed the methodology outlined in the founding texts and have attempted to meet the 'canons of good science'. Others (e.g., Fujimura, 1987; Star, 1989) have been influenced by perspectives such as social constructivism and postmodernism, and they have adapted grounded theory to accommodate these influences.

Strauss and Corbin (1994) acknowledge the influence of other perspectives on grounded theory. Indeed, their own understanding of the methodology is also evolving under the influence of contemporary intellectual trends. In a recent article, Strauss and Corbin (1994: 279) state that theory "is not the formulation of some discovered aspect of a pre-existing reality 'out there'", but an interpretation which is influenced by the pre-conceptions of the researcher and 'some degree of reciprocal shaping' during interactions with those who are researched. In other words, grounded theorists are beginning to move away from the idea that there is an external reality, which can be investigated in an objective manner to produce a 'true' explanation of events. However, Strauss and Corbin (ibid.) argue that these modifications have not altered the basic principles of grounded theory.

Strauss and Corbin (ibid.: 275) argue that grounded theory is a general methodology, "a way of thinking about and conceptualizing data", which is easily adapted. However, they do identify a number of 'core' features, which are so integral to the approach that their abandonment would indicate a significant departure. They are "the grounding of theory upon data through data-theory interplay, the making of constant comparisons, theoretical coding and the development of theory" (ibid.: 283). In other words, the 'essence' of grounded theory lies in a commitment to develop theory inductively through interplay with data, a process which involves the systematic and explicit coding of data through comparative analysis.

This is the sense in which grounded theory is integrated into the new hybrid. The 'essence' of the approach is adopted. There is a commitment to 'explain' human-computer interaction in complex organizations by developing theory, consisting of concepts and conceptual relationships. Theory is developed inductively using the method of constant comparison. That is, concepts and conceptual relationships are generated by comparing incidents and events in data for their similarities and differences. In other words, the aim is to look for *patterns*. Other aspects of grounded theory's complex coding procedure are rejected, as described in the next chapter. However, a commitment to search for patterns remains, based on the assumption that discernible patterns exist in the world.

Few assumptions have been made so far about the world to be investigated and what can be known about it. Although I have rejected the notion of a single external reality, I have not provided an alternative ontology. I have rejected the assumption that human-computer interaction in complex organizations can be described solely in terms of 'ethnomethods', but I have not described other possible dimensions of the phenomenon. The remainder of this chapter draws a more detailed picture of the understanding of human-computer interaction which informed this study. It considers the relevance of social constructivism for understanding human-computer interaction, re-examines ethnomethodology in the light of social constructivism and considers the potential contribution of social worlds theory, before synthesizing aspects of all three perspectives with grounded theory to form a coherent approach to the study of human-computer interaction in complex organizational settings.

Social constructivism

'Social constructivism' is an umbrella term, which denotes a group of related sociological approaches to technology. The approaches include the systems approach (Hughes, 1987) actor network theory (Latour, 1987; Callon, 1991) the social construction of technology (Pinch and

Bijker, 1987; Bijker, 1992) and the idea of technology as text (Woolgar, 1991).

Social constructivist perspectives are characterised by a 'seamless web' approach to the relationship between technology and society, and an interest in opening up the 'black box' of technology. Unlike traditional 'determinist' positions, social constructivist perspectives do not regard technology as an external and independent force, which causes change in society. Rather, technology is seen as grounded in social forces (Bijker, Hughes and Pinch, 1987). Hence, the focus of social constructivism is not the impact of technology on society, but the influence of society on the actual 'content' of technology. However, social constructivism goes further than arguing that technology is merely influenced or 'shaped' by social forces. It argues that technology is constituted by social forces: the technical *is* social.

Social constructivists hold a range of views about exactly how the technical can be understood as social. Hughes (1987) integrates the social, technical, economic and political aspects of technology development using a 'systems' metaphor. He argues that 'technological systems', such as electricity and power systems, are composed of interacting elements, which derive their individual characteristics from the system as a whole. Hence, the 'technical' is at least partially constituted by the 'social' and vice versa. Callon (1991) and Latour (1991, 1992) also integrate the 'technical' and the 'social' into heterogeneous systems of interacting elements. However, they collapse the dichotomy between the 'social' and the 'technical' to an even greater extent than Hughes (1987), giving both human and non-human elements 'actor' status: Latour (1992) argues that the distinction between 'human' and 'non-human' is itself a social construction.

The central tenet of Pinch and Bijker's (1987) approach is that the content of technological artefacts is socially constructed. Pinch and Bijker (ibid.) argue that artefacts are 'interpretively flexible'. That is, they are open to interpretation and have different meanings for different groups of people. In order to understand why technologies are designed and used in particular ways, we need to look at the social circumstances in which they are interpreted (Pinch and Bijker, ibid.; Bijker, 1992).[16] Woolgar (1991) also emphasizes the 'interpretive flexibility' of technological artefacts. However, he takes this concept a step further: he argues that machines *are* their interpretations. Unlike the other studies discussed so far, Woolgar's focus is computer systems. Using the metaphor of technology as 'text', Woolgar (ibid.) casts designers as the 'writers' of computer systems and 'users' as the 'readers'. He argues that computer systems exist for users as a variety of possible 'readings', which are configured to a significant extent by the way that 'writers' or designers organise the 'text'.

The argument that computer systems are socially constructed artefacts with 'interpretive flexibility' has significant implications in the context of human-computer interaction. According to this view, what a computer system is, what it can be used for, its 'capacities' and 'effects' are not determined solely by the technical properties of the machine. They are the result of negotiated and re-negotiated interpretations, which are constructed in the specific circumstances in which design and use occur. So, for example, the relative merits of one interface design over another are not simply a reflection of technical capacity, but are interpretations which are constructed during the system's development and use (Cooper et al. 1995). Moreover, the concept of the 'interface' is itself a social construction. There is nothing 'obvious' about the generally accepted boundaries of this and other familiar concepts which

[16]This approach is discussed in more detail in the next section.

constitute the discourse of HCI. According to social constructivism, boundaries between the 'social' and the 'technical', the 'user' and the 'computer', are topics for empirical investigation (ibid.).

The next section examines Pinch and Bijker's (1987) approach, the Social Construction of Technology (SCOT), in more detail. With its focus on the interpretation of technological artefacts during design and use, this approach shows particular potential for the study of human-computer interaction. The concept of 'interpretive flexibility' is considered in more detail, and other key concepts of the SCOT approach are introduced. The following section then examines the relevance of these concepts for human-computer interaction.

The Social Construction of Technology

Pinch and Bijker's (1987) approach to technology has its roots in the sociology of scientific knowledge. Sociologists and philosophers working in this area argue that scientific 'facts' are social constructions, and that explanations for what is accepted and rejected as 'fact' should be sought in the social world rather than the natural world (Zimmerman, 1988). Pinch and Bijker (1987) argue, similarly, that technology is socially constructed, and that explanations for the 'success' and 'failure' of technological artefacts should be sought in the social world. A key concept of this approach is the idea that the development of an artefact 'could have been otherwise'. That is, artefacts whose form and function we now take for granted have multiple, rather than linear, development paths. In order to explain why an artefact comes to have a particular form and function, we need to look at the circumstances in which it was developed.

Pinch and Bijker (ibid.) introduce their approach in an analysis of how the bicycle was developed. They argue that there were many versions of the 'bicycle' during its development and that it was several decades before the artefact resembled its present form. Pinch and Bijker (ibid.) explain this multi-directional development path by examining the interests of the different social groups for which the bicycle had some relevance. They identify several 'relevant social groups', including the manufacturers and users of bicycles, as well as sub-groups such as women cyclists and sports cyclists. Pinch and Bijker (ibid.) argue that each of these groups interpreted the bicycle differently: each group attributed different meanings and problems to the artefact. For example, the problem for women cyclists was dress, while the problem for sports cyclists was speed. Hence, the groups had conflicting interests.

Pinch and Bijker (ibid.) argue that the bicycle eventually stabilized and began to resemble the artefact that we now take for granted, once the conflicting interests of different groups had been resolved. They term this process 'closure'. Pinch and Bijker argue that it is not necessary for conflicts to be literally solved in order for 'closure' to take place: the important point is that relevant social groups *see* the problem as being solved. In the case of the bicycle, this happened when the key problem for two important groups was redefined: sports cyclists and the general public had been opposed to the air tire, originally introduced to solve the 'problem' of excessive vibration. However, when it was discovered that the air tire greatly increased speed, opposition from these groups died down. The meaning of the air tire was translated from a solution to the problem of excessive vibration to a solution to the problem of how to go as fast as possible.

Pinch and Bijker (ibid.) explain the multiple meanings and problems attributed to artefacts using the concept of 'interpretive flexibility', discussed earlier. In their analysis of the bicycle, they argue that there is flexibility in the way that artefacts are interpreted during development. However, in a study of the modern fluorescent lamp, Bijker (1992) also argues that there is flexibility in the way that artefacts are interpreted in use. Bijker (ibid.) argues that after the lamp left the laboratory, it was "continually reshaped and redesigned" by the various social groups who used it. He concludes that 'design' continues long after artefacts leave the laboratory, and he suggests that "to understand the design process of technical artefacts, we should not restrict ourselves to the social groups of design-room engineers or laboratory personnel ... even in the diffusion stage, the process of invention continues" (ibid.: 97).

The social construction of computer use

The idea that technical artefacts are interpreted and re-interpreted in use has obvious relevance for human-computer interaction. However, the implications of the SCOT approach for computer use have yet to be explored. Although several recent studies (Woolgar, 1991; Cooper et al., 1995; Low and Woolgar, 1993)[17] have examined how computer systems are socially constructed during design, no consideration has been given to the social construction of computer systems in use. In fact, little consideration has been given to the social construction of any technology in use. Researchers working in the SCOT tradition (e.g., Pinch and Bijker, 1987; Bijker, 1995; Elzen, 1986) have concentrated on the development or 'production' of technology, rather than its use

[17]These ethnographic studies were not conducted within the framework outlined by Pinch and Bijker (1987). However, they are based on an understanding of technology which shares much in common with the SCOT approach and which also deploys the concept of 'interpretive flexibility'.

or 'consumption'. Moreover, the few studies which have considered technology use (e.g., Pinch, 1992) are not based on actual observations of people's interactions with technology, but on historical documents.

Pinch and Bijker (1987) developed the SCOT framework to demonstrate that artefacts which we now take for granted once meant different things to different people. They wanted to show that technological artefacts are 'interpretively flexible', and that they have multi-directional, rather than linear, development paths. Pinch and Bijker (ibid.; Bijker, 1992; Bijker, 1995) did this by tracing the development of artefacts through historical documents, and by developing a theoretical framework to suit this specific goal and data type. This raises the question of whether concepts developed to understand technology development in these circumstances are, in fact, applicable to observations of people's interactions with computer systems.

Orlikowski (1992) claims that the SCOT framework is relevant for understanding people's interactions with technology. She suggests that the concept of 'interpretive flexibility' can be used to account for unexpected and unanticipated uses of technology. She observes that when technologies are implemented in organizations, they are often used in ways that were not intended. She argues that this occurs because users are engaged in constituting technology physically and socially during use. Although Orlikowski (ibid.) provides no data to support the claim that technologies are interpretively flexible in use, the concept does seem to have relevance in the context of computer use.

When computer systems are implemented in 'real world' settings, they are often used in ways that were not intended (Quintas, 1993, Lyytinen, 1988). In the HCI literature, this phenomenon is generally attributed to 'usability' problems. That is, a failure on the part of designers to meet the needs of users. Some authors (e.g., Karat, 1988) suggest that this failure results from an inadequate understanding of the user's cognitive performance, while others (e.g., Whiteside et al. 1988; Holtzblatt and Jones, 1993; Somerville et al. 1992) argue that it results from an inadequate understanding of 'what users actually do' in their work. However, the concept of 'interpretive flexibility' implies that to understand how people use computer systems, designers need to look further than users' working practices and individual cognitive performance: shared interpretations underlie what people do with computer systems.

According to the SCOT model, explanations for unanticipated and unexpected computer use are to be found in users' perceptions or interpretations of computer systems. A single computer system may be perceived or interpreted differently by different groups of users. That is, users may have different perceptions of what a computer system is, what it is for, its capacities and its effects. In order to understand how users interpret computer systems, designers need to look at the circumstances in which they are interpreted. That is, they need to look at the use context.

SCOT is not the only theoretical framework which recommends looking at the context of technology use. Ethnomethodologists (e.g., Suchman, 1987; Heath and Luff, 1992) also investigate the 'real world' contexts in which technology is used. Indeed, these approaches have much in common. They both view social order as constituted by meaning or understanding, and they both recognise that technology may have different meanings for different people. However, while the SCOT approach aims to identify these meanings (Pinch and Bijker, 1987; Bijker, 1992; Bijker, 1995), ethnomethodologists are not so much interested in the meanings themselves as the 'work' which makes the meanings possible. One of Garfinkel's (1967) central claims is that shared understandings are not pre-given, but produced in and through member's actions in specific circumstances. For ethnomethodologists, shared understandings are generated by the character of action itself and "there is nothing of interest under the skull" (O'Keefe, 1979). For social constructivists, on the other hand, what is 'under the skull' is the primary interest.

One leading ethnomethodologist, Button (1993a), argues that because SCOT focuses on 'what is under the skull', it fails to account for the 'actual use' of technology. Button (ibid.) claims that Pinch and Bijker (1987) ignore "the interactional practices and processes through which technological work is organised and the technology itself is produced" (ibid., 20). There is some substance to this (ibid.) claim in that, as noted earlier, Pinch and Bijker's (ibid.; Bijker, 1992; Bijker, 1995) studies are not based on observations of 'interactional practices', nor do they aim to explicate such practices. Rather, Pinch and Bijker's (1987) goal is to explicate the meanings which become attached to technology. However, Button (ibid.) goes on to argue that the reason for Pinch and Bijker's (1987) failure to account for people's interactions with technology is that they are not genuinely interested in technology. He argues that they see technology merely as a vehicle to advance a theory of social reality.

Pinch and Bijker (ibid.) have a relativist-constructionist view of reality. Like ethnomethodologists, they view reality as socially constructed. Pinch and Bijker's (ibid.) ontological position is obviously central to their theoretical framework. It means that they view technology as something which is socially constructed and which can be interpreted differently by different people. Hence, their research aims to reveal the different ways in which technology is interpreted. Button (1993) claims that this ontological position renders the SCOT programme less useful to the development of computer systems than the ethnomethodological programme, which has a 'genuine' interest in people's interactions with technology. However, it is not clear why this should be the case.

Neither the SCOT framework (Pinch and Bijker, 1987) nor the programme of ethnomethodology (Garfinkel, 1967) were developed for the study of human-computer interaction. They are both sociological research programmes. In a sense, they both use technology as a vehicle for advancing theories of sociological interest, and their studies aim to explicate just those aspects of people's interactions with technology which further these theories. Hence, the SCOT framework defines the context of technology use in terms of people's interpretations or perceptions of technology, while ethnomethodology defines it in terms of their interactions. To date, ethnomethodological studies (e.g., Suchman, 1987; Heath and Luff, 1992; Hughes et al. 1992) have had most influence within the field of HCI, and interactions with technology have received far more attention than perceptions of technology. However, this strategy of inquiry is lacking in a number of respects.

Ethnomethodologists attempt to identify the interactions or 'ethnomethods' through which shared perceptions are generated (Cuff, Sharrock and Francis, 1990). They do this by conducting detailed studies of interactions within small groups of people (e.g., Suchman, 1987; Heath and Luff, 1992). This strategy assumes that the generation of shared perceptions can be described solely in terms of observable interactions within a single group. However, most organizational settings constitute multiple groups which interact with each other and with groups outside the setting. Moreover, people are usually members of not one, but many different groups (Lea and Giordano, 1993).[18] Interaction between as well as within groups could be important in explaining how people perceive computer systems and what they do with them.

Pinch and Bijker's (1987; Bijker, 1992; Bijker, 1995) focus on how different groups interpret technology has potential for the investigation of human-computer interaction in complex settings. However, to inform the design of computer systems, an investigation must do more than explicate the different ways in which computer systems are interpreted. In this sense, Button (1993) is right to question the potential of the SCOT approach (Pinch and Bijker, 1987) to inform systems design. What is needed is an approach which explicates both perceptions of and interactions with computer systems. In other words, the concept of 'interpretive flexibility' must be extended to include the actual acts and practices through which computer systems are interpreted. This is the sense in which the concept is used in this study.

While the concept of 'interpretive flexibility' does seem useful for understanding what people do with computer systems, the notion of 'closure' is less obviously relevant. In the SCOT approach (Pinch and Bijker, 1987), 'closure' describes a process of stabilisation, whereby the problems of different social groups with respect to an artefact 'disappear' and consensus emerges. At this point, the 'interpretive flexibility' of an artefact also starts to 'disappear' and people begin to take the artefact for granted. Orlikowski (1992) applies this concept to technology implementation and use. She argues that when 'closure' takes place, the use of technology in organizations becomes rigid and

[18]This idea of organizations as composed of relatively 'fluid' groups will be discussed in more detail shortly

institutionalized. The technology is less open to modification and "assumes a solidity and stability that belies its potential interpretive flexibility" (ibid., 421).

In Pinch and Bijker's (1987; Bijker, 1992, Bijker, 1995) studies, 'closure' helps to explain how artefacts which used to be 'interpretively flexible' came to be 'taken for granted'. Pinch and Bijker's (ibid.) research aims to recover the 'interpretive flexibility' of historical artefacts in retrospect. In order to do this, they must explain how and why the 'interpretive flexibility' of artefacts disappeared. In other words, Pinch and Bijker (ibid.) need the concept of 'closure'. However, this concept does not have the same relevance for contemporary studies of computer systems in use: it makes little sense to suggest that at a particular time computer systems are 'fixed', and the process of interpretation ends. Although the technology may appear to be more stable at some times than others, the potential for re-interpretation always exists. If computer systems are interpreted within specific circumstances, then, should those circumstances change, they may be re-interpreted. Hence, the concept of 'closure' is not part of the theoretical framework which informs this study.

The third major element of the SCOT approach is the concept of 'relevant social groups'. A 'relevant social group' is a group for which a technology has some relevance and for which "all members share the same set of meanings attached to a specific artefact" (Pinch and Bijker, 1987: 30). Pinch and Bijker (ibid.) use this concept to demonstrate the 'interpretive flexibility' of artefacts. That is, they use it to demonstrate that the same artefact can have different meanings for different groups of people. However, there is a problem with the concept 'relevant social group': Pinch and Bijker (ibid.) did not develop the concept to account for observations of group interaction, they developed it to trace these interactions through written text.

Pinch and Bijker (ibid.; Bijker, 1992) identify 'relevant social groups' by 'following the actors' in historical documents. They argue that this is a relatively simple process because actors themselves are explicit about group membership (Bijker, 1992: 77):

> While following the actors by reading historical documents, the researcher notes each actor and every social group that is mentioned. Subsequently those new actors and social groups are also followed, and at some point no more new names or social groups will be encountered.

The 'relevant social groups' which emerge from this process comprise large numbers of people. For example, in Pinch and Bijker's (1987) study of the bicycle, several different manufacturers form one group, while 'women cyclists' constitute another. These huge groups of people are represented as mutually exclusive, homogeneous units, whose members all hold the same set of meanings with respect to an artefact. Strauss's work on social worlds theory (1978, 1982, 1985), however, suggests that this framework is too simplistic to account for interaction between groups. The next section considers the relevance of social worlds theory for understanding group interaction in complex organizations.

Social worlds theory

Social worlds theory (Strauss 1978, 1982, 1985) is a theoretical framework for describing and analysing the organization of social life. Strauss (1978) argues that society can be conceptualised as a mosaic of social worlds. Social worlds are groups or communities with shared commitments to particular activities and ideologies. They form the 'building blocks' of collective action. Social worlds include leisure worlds such as 'cricket', industrial worlds such as 'oil' and occupational worlds such as 'medicine' (Strauss, 1982). Each social world is composed of smaller worlds (sub-worlds) and organizations. For example, the social world of 'medicine' is composed of sub-worlds such as 'geriatrics' and 'general practice' and organizations such as clinics and hospitals.

Social worlds theory has its roots in the symbolic interactionist tradition (Strauss, 1978). Symbolic interactionism is a theory of social activity, which is particularly associated with the writings of Mead (1939) and Blumer (1969). This theory emphasizes that to understand the way people act, you need to understand how they give meaning to their circumstances (Cuff et al., 1990). In other words, meaning is seen as central to action. Symbolic interactionism is a relativist-constructivist approach, which aims to make general statements about social life by investigating activity in specific circumstances. Social worlds theory has inherited this aim and ontology.

Social worlds theory conceptualises organizations in a different way to traditional organizational theory. While most organizational theory (e.g., Pfeffer, 1979; Meyer and Scott, 1983; Hannan and Freeman, 1990) characterises organizations in terms of formal, hierarchical relations and well-defined boundaries, Strauss (1978) describes organizations as complex units of collective action, which have fuzzy, porous boundaries. Organizations do not exist in isolation: they exist in a larger arena in which they interact with other organizations. Moreover, each organization is itself composed of smaller worlds. These worlds are cross-cutting, rather than mutually exclusive, and individuals are typically members of many different worlds. Furthermore, the structure of worlds is highly fluid. It shifts as patterns of commitment alter and re-organize.

This picture of organizations suggests that Pinch and Bijker's (1987; Bijker, 1992) definition of 'relevant social groups' is too simplistic to describe the way that groups form in complex settings. It fails to recognise that groups are fluid, that their boundaries are permeable and that individuals can be members of more than one group. Social worlds theory also implies that the SCOT view of group interaction is over-simplified. While Pinch and Bijker (ibid.) describe group interaction in terms of conflict generation and resolution, Strauss (1982) argues that other important processes also take place, such as negotiation, gaining social legitimation and establishing and maintaining group boundaries.

Strauss (1978) emphasizes the need to conduct empirical investigations of organizations and their boundaries. He argues that formal representations of organizations should be treated as problematic, and that researchers should focus on *how people organize themselves*. He also stresses that individual work settings must be considered within a wider arena. Every organization interacts with other organizations in different social worlds. Moreover, when people enter the workplace, they do not leave behind their commitment to other worlds. They bring aspects of those worlds into the workplace with them (Strauss, 1982).

Social worlds inquiry locates work settings in this larger arena of intersecting social worlds (ibid.). A single organization is often taken as the unit of analysis and considered in terms of both its intersection with and segmentation into other worlds. Strauss (1978) argues that in order to investigate an organization's relations within this larger arena, the symbolic interactionist tradition of fieldwork must be modified. Symbolic interactionist ethnography is based on focused fieldwork and interviewing, which aims to elicit people's perceptions of their circumstances. Strauss (ibid.) argues that these methods must be supplemented by the use of documents and other data sources pertaining to the multiple social worlds with which organizations intersect.

Social worlds theory has a number of implications for the investigation of human-computer interaction in complex organizational settings. If groups and organizations are 'fluid' and their boundaries are porous, then formal representations of their boundaries should be treated sceptically. If groups and organizations intersect and interact, then the way computer systems are perceived and used within one group may influence the way they are perceived and used in other groups. Moreover, if individuals belong to different groups in different areas of their lives, they may bring their membership of 'outside' groups into their interactions with individual groups. Hence, the way computers are perceived and used in the workplace may be influenced by the way they are perceived and used outside the workplace. Moreover, multiple group membership means that groups should be treated as heterogeneous rather than homogeneous entities, since members are unlikely to have the same membership of other groups or the same perceptions of computer systems. This is the understanding of groups and organizations which informs the hybrid methodology.

The next section considers the relevance of an approach which is related to social worlds theory. Star and Griesemer (1989) draw on Strauss's (1978, 1982, 1985) framework to explore what happens when people from different social worlds work together. They suggest that when social worlds intersect, 'boundary objects' are created.

'Boundary objects'

According to social worlds theory, social activity often involves interaction between people from different social worlds (Strauss, 1978). This can happen when different organizations interact or even when people from the same organization interact, since a single organization may straddle multiple social worlds. Star and Griesemer (1989) describe the evolution of such an organization; the Museum of Vertebrate Zoology at the University of California, Berkeley. The establishment of this museum involved participation from a number of different worlds; government officials, professional scientists, amateur naturalists, university administrators and private sponsors. Star and Griesemer (ibid.) argue that the venture was a success because actors from the different worlds were able to manage the tensions which arise when worlds intersect. One of the ways they were able to do this was by creating 'boundary objects'.

'Boundary objects' are objects which inhabit several different intersecting social worlds simultaneously and which meet the demands of each one (Star and Griesemer, 1989). They may be abstract or concrete. They have different meanings in different worlds and are plastic enough to adapt to local needs, yet robust enough to maintain a common identity. Boundary objects are essentially a 'means of translation' between worlds. Star and Griesemer (ibid.) identify a number of boundary objects involved in the creation of the museum. The museum itself was a boundary object: it meant different things in each of the different worlds. For the professional scientists, it was a means of gaining support for research, for the amateur naturalists, it was a way of gaining credibility for conservation efforts, while for the trappers, the museum was a source of income. The state of California also took on the status of a boundary object. The goal of "preserving

California" served the regional mandate of the university administrators, as well as the conservation goals of the amateur naturalists and professional scientists.

Goguen (1993) argues that the concept of 'boundary objects' can usefully be applied to computer systems. He suggests, for example, that databases can be viewed as boundary objects, since they present information in different ways to different users. Requirements documents are also boundary objects, since they must serve many different stakeholders. Bowers (1994) uses the concept of 'boundary objects' in the context of CSCW systems. He argues that when CSCW systems are implemented in organizations, they have 'variable significance' (ibid.: 295):

> A technology for documenting decision making rationale may equally appear to be a device for increasing the accountability that workers have for all aspects of their work. A technology which may support the transformation of work may seem to another party to be inadequately sensitive to existing practices.

Bowers (ibid.) suggests that designers could help users to manage the 'variable significance' of systems in organizational settings by actually making the development of 'boundary objects' an aim of design.

Like the concept of 'interpretive flexibility' (Pinch and Bijker, 1987), the idea of 'boundary objects' is based on a relativist-constructivist view of the world. Both concepts imply that a single computer system may be interpreted differently by different people. However, the concepts are not equivalent. While 'interpretive flexibility' is a property that computer systems have (Pinch and Bijker, 1987), 'boundary objects' are artefacts that people create (Star and Griesemer, 1989). People from different social worlds create boundary objects in order to manage the dilemmas which arise when they work together. Boundary objects may be abstract or concrete: what is important, is their ability to simultaneously satisfy the needs of multiple social worlds. This is the sense in which the concept 'boundary objects' is used in the hybrid methodology

A final framework

This chapter has introduced several different approaches to the study of social activity and considered their relevance for the study of human-computer interaction. This final section summarizes the understanding of human-computer interaction which emerged from consideration of these approaches and outlines a methodology for investigating human-computer interaction in complex organizational settings.

The understanding of human-computer interaction which informs this study is based on three different approaches to social activity; social constructivism, social worlds theory and ethnomethodology. None of the approaches is appropriate in a pure form in the context of human-computer interaction, so the hybrid incorporates certain aspects of each approach and rejects others.

The hybrid methodology takes its ontological assumptions from social constructivism. Reality is regarded as socially constructed and computer systems are seen as socially constructed during both design and use. That is, the 'capacities' and 'effects' of computer systems are not determined purely by their technical properties. Rather, they are the outcome of negotiated and re-negotiated interpretations which are constructed in the specific circumstances in which design and use occur. Computer systems are said to be 'interpretively flexible'; they may have different meanings for different people (Pinch and Bijker, 1987). This study aims to explicate these shared meanings on the assumption that they are significant in explaining people's interactions with computer systems.

Although the study aims to explicate the meanings which become attached to computer systems, it aims to relate these meanings to what people actually do with the technology. Thus, it extends the concept of 'interpretive flexibility' to examine the actual acts and practices through which computer systems are interpreted. This emphasis on 'what people actually do' with computer systems has its roots in an ethnomethodological understanding of human-computer interaction (Garfinkel, 1967; Button, 1993).

The hybrid methodology not only views the design and use of computer systems as socially constructed: it also regards the discourse of human-computer interaction as socially constructed. In other words, familiar concepts such as the 'user' and the 'computer' and dichotomies such as the 'social' and the 'technical', the 'design' and 'use' phases, are regarded as topics for empirical investigation. This 'sceptical' approach to the boundaries of 'taken for granted' concepts has its roots in social constructivism (Cooper et al., 1995).

The methodology also takes a sceptical approach to organizational and group boundaries. Groups and organizations are seen as fluid units with porous boundaries (Strauss 1978, 1982, 1985). Each unit exists in a larger arena, where it interacts with other groups and organizations, and where individuals are members of more than one group. Hence, the study assumes that the way computer systems are interpreted and used in one group may influence the way they are interpreted and used in other groups. Groups are seen as heterogeneous units, whose members have variable interpretations of computer systems. Formal representations of group and organizational boundaries are therefore treated as problematic and subjected to empirical investigation. This understanding of group interaction is based in social worlds theory (ibid.).

Interaction between groups or 'worlds' may also involve the creation of 'boundary objects' (Star and Griesemer, 1989). Boundary objects are 'plastic' enough to adapt to the local needs of individual worlds, yet 'robust' enough to maintain a common identity across worlds: they simultaneously inhabit and meet the demands of multiple worlds (ibid.). Boundary objects may be abstract or concrete. Hence, computer systems themselves may be viewed as boundary objects, as may the products of computer use or even conceptualizations of computer systems.

This understanding of human-computer interaction requires a form of 'ethnographic' inquiry, which is appropriate for its specific combination of assumptions. The investigation should explicate both people's perceptions of and interactions with computer systems. It should also consider the possibility that these perceptions and interactions are influenced by perceptions of and interactions with computer systems outside the immediate group and organization in which computer use takes place. Moreover, the inquiry should generate theoretical findings, from which conclusions can be drawn and recommendations made.

This commitment to theory generation is based in grounded theory (Glaser and Strauss, 1967; Strauss and Corbin, 1990). The methodology adopts the basic principles of grounded theory, although it rejects the approach's ontological and epistemological assumptions. The study aims to generate a theoretical 'explanation', consisting of concepts and conceptual relationships which are 'grounded' in ethnographic data. The 'explanation' is 'grounded' in the sense that it is based on patterns observed in data, and the understanding of human-computer interaction which informs the study is tested against data. However, the 'explanation' is not an accurate representation of reality and the 'canons of good science' are rejected as judgement criteria, because reality is seen as socially constructed and findings are regarded as value-mediated. This study aims to convince readers of the value of its explanation by making explicit how the explanation was generated. It lays bare the understanding of human-computer interaction which informed the study and uses self-exemplifying principles of analysis. No claims are made about the predictive power of the 'explanation': although cause-effect relationships are established, they do not provide a basis for predicting with certainty the effects of specific interventions. The reasons for this limitation will be discussed in detail in a later chapter.

The next chapter describes how this hybrid methodology was used to investigate human-computer interaction in one specific complex organizational setting.

Chapter 3: Methodology

Introduction

This chapter describes a study of human-computer interaction, which was carried out using the methodology outlined in the previous chapter. The aim of the study was to construct a theoretical explanation of human-computer interaction in a group of primary school classrooms. Whereas most accounts of human-computer interaction in real world settings (e.g., Suchman, 1987; Bowers, 1994) describe interactions with a particular computer system or application, this study aimed to explain human-computer interaction in classrooms in broader terms: It asked why certain applications were used rather than others, where, when and how the applications were used.

The first three sections of this chapter discuss why primary school classrooms were chosen as the setting for this investigation of human-computer interaction. These sections argue that classrooms are an appropriate setting in which to apply the hybrid methodology outlined in the previous chapter, because they are (a) a complex organizational setting, (b) a commonplace setting for computer use, (c) a setting where computers are failing to deliver expected benefits and (d) a setting where this problem has yet to be explained. The fourth section of this chapter describes the particular classrooms which served as the sites for field study, while the remaining sections describe the methodology which was used to investigate computer use in these classrooms.

The Classroom: A complex setting for computer use

The first chapter emphasized that most real world studies (e.g., Suchman, 1987; Heath and Luff, 1992; Heath et al., 1993; Hughes, Randall and Shapiro, 1992) are ethnomethodological studies of relatively closed settings, which focus on interactions within small groups of people. These highly constrained settings are in many ways unrepresentative of the vast majority of settings in which computer use takes place: Most computer use occurs in factories, shops, hospitals, offices and other complex settings, which constitute multiple groups of people, who not only interact with each other, but also with groups outside the immediate setting.

In addition to these studies of closed settings, several studies of office work (e.g., Suchman, 1983; Suchman and Wynn 1984; Rouncefield et al. 1994) have been carried out over the last few years. Offices represent a complex setting in the sense described above, and they are a commonplace setting for computer use. However, like closed control room type settings, offices are places of work: almost all ethnographic studies are conducted in settings, where computer use forms part of work activity. These studies are carried out within a branch of ethnomethodology, which is concerned with explicating work practices (Button, 1993). Although computers play a significant role in domestic, leisure and educational activity, almost nothing is known about computer use in these other areas of life.

Primary school classrooms are complex in the organizational sense described earlier. Each classroom contains up to 40 pupils, a teacher and possibly one or more classroom assistants. These classrooms exist within schools, and schools exist in the larger arenas of their local communities, Local Education Authorities (LEAs) and the National education system. Schools not only interact with other organizations in these arenas: they are also accountable to and subject to the policies of 'official' bodies, such as the school board of governors, LEA officers and the Department for Education (DfE).

Classrooms are also complex in terms of the activity which takes place there. Classrooms are generally associated with learning activity. This is the place where society educates children for later life. Children are educated by teachers, for whom the classroom is a workplace: teaching is 'work' (Nias, 1989). There is also a sense in which learning is 'work'. Children are obliged to attend school. They have tasks to complete and goals to attain. However, childhood is also a time of 'play' and this activity, too, forms a significant part of school life.

This complex environment formed an ideal setting in which to deploy the hybrid methodology outlined in the previous chapter. Unlike the 'control room' settings investigated in ethnomethodological studies (e.g., Heath and Luff, 1992; Hughes, Randall and Shapiro, 1992), the classroom is a commonplace setting for computer use. The classroom is also a 'complex' setting for computer use, both in terms of the type of activity which takes place there and the different groups of people (with membership of multiple social worlds) who are involved in this activity. Furthermore, as the next two sections of this chapter demonstrate, there is a 'problem' with classroom computer use, and this problem has yet to be explained.

During the last 15 years, the British government has spent over £187 million promoting the use of computers in schools (DfE, 1995b). Most primary school classrooms have a computer (DfE, 1993), and legislation exists to ensure that they are used in educationally effective ways (DfE, 1995). However, there is evidence to suggest (e.g., DES, 1991; DES, 1992; Ofsted, 1993; DfE, 1993) that the technology is failing to deliver expected benefits in primary classrooms. Computers are not used as educational technologists (e.g., Papert, 1980) anticipated or as legislation (DES, 1989) demands. They are not used to develop 'higher order' skills through active, exploratative learning. Instead, they are used to develop basic skills through copy typing and rote learning.

The following section discusses the problem of classroom computer use in more detail. It examines the background to the implementation of computers in UK classrooms, the legislation which governs computer use and evidence that computers are failing to deliver expected benefits.

The 'problem' of classroom computer use

Computers first arrived in British primary schools over 25 years ago (Boyd-Barrett, 1990). Initially, few schools had access to the technology (Underwood and Underwood, 1990), but the availability of machines has increased dramatically, and now most classrooms have computers (DfE, 1993). Widespread access to the technology has been made possible by a series of government schemes, which aimed to both get computers into classrooms and influence their use (Boyd-Barrett, 1990).

The first scheme to get computers into primary classrooms was launched in 1982 and was followed by a succession of similar schemes over the next ten years (Boyd-Barrett, 1990, Roper, 1992). These schemes were motivated by commercial as well as educational factors (Trott, 1988; Boyd-Barrett, 1990; Roper, 1992). Government grants were tied to the purchase of computers from British manufacturers, and software supplies, teacher training and other services were also restricted to the use of these computers. Hence, most computers in British primary schools are manufactured by a company called Acorn (DfE, 1993). Standardising the technology in this way facilitated the provision of support services (Collis and Oliveira, 1990). However, it also gave a much needed boost to the domestic IT industry (Boyd-Barrett, 1990; Roper, 1992).

Schemes to influence the use of computers were also motivated by a mixture of commercial and educational factors. The brief of the first major scheme, launched by the Department of Education and Science in 1980, was to promote the use of computers in technical and commercial subjects in secondary and further education (Thorne, 1987). Primary schools were not included until the later stages of the scheme, since the aim was to produce computer literate school leavers rather than improve general standards in education. However, in 1987, there was a change of emphasis in government policy: computers were to be used not only to prepare pupils for an information society, but also to enhance the quality of teaching and learning (Boyd-Barrett, 1990). In 1988, this change of policy was recognised in National Curriculum legislation (DES, 1989).

National Curriculum legislation establishes a centrally-dictated curriculum for all pupils aged 5-16 in state-maintained schools in England, Wales and Northern Ireland (Coupland, 1990). Information Technology (IT) is given the status of a 'cross-curricular' skill: It is to be used throughout all subjects and areas of the curriculum (DES, 1989). IT finds statutory expression in two parts of the legislation: the Technology Order of the Curriculum identifies a specific body of IT knowledge and skills (the IT Capability) which is to be taught and assessed, while other foundation subject Orders also include components specifying the use of IT (ibid.).

The IT Capability outlines a minimum statutory entitlement to computer experience for school-age pupils (ibid.).[19] It comprises five different aspects; communicating information, handling information, modelling, measurement and control, as well as applications and effects (DES, 1989). Each aspect has associated 'programmes of study' and 'statements of attainment'. Programmes of study specify what pupils should be taught, while statements of attainment set out the 'knowledge, skills and understanding' that they are expected to develop (NCC, 1990). Attainment targets are assessed by teachers at the end of each key stage of pupils' education.[20] There are four 'key stages'. Primary level education comprises key stages one and two: stage one includes pupils age five to seven; stage two pupils aged seven to eleven. The IT Capability came into effect for six and eight year olds in 1990, for pupils aged six to nine in 1991, and for all remaining primary age pupils in 1993 (ibid.).

The IT Capability not only compels teachers to use computers in classrooms, it specifies how they should use them. In order to meet attainment targets for each of the five different aspects, pupils need to experience a wide range of applications (ibid.). The average seven year old should be able to; use a word processor to draft a story and illustrate it with graphics, classify objects using a simple sorting

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[19]This aspect of the National Curriculum was altered recently as part of a general revision of the legislation, carried out in response to teacher complaints that it was too prescriptive and the adminstration of tests too time-consuming (Dearing, 1994). The revised version of the IT Capability retains the emphasis of the original Order in a simplified and streamlined form (DfE, 1995). However, this new Order does not come into effect until August 1995, so the IT Capability discussed here is the original version (DES, 1989).

[20]There are no statutory test for IT. Teachers assess pupils on the basis of ordinary classroom work or they may administer one of a number of standard assessment tests developed by the School Examinations and Assessment Council (SEAC, 1992).

program, store information in a database, use an adventure program to construct a map and control an external device with simple instructions. By the age of eleven, they should have progressed to; use a word processor for more demanding tasks (such as creating a class newspaper), interrogate a database, make and justify predictions using a modelling program, program in LOGO, devise instructions for a turtle graphics program or programmable robot and justify the use of IT in some situations and not others (ibid.).

The IT Capability reflects the way that many educational technologists (e.g., Papert, 1980; Chandler, 1984) would like to see computers used in classrooms. There is evidence (e.g., Papert, 1980; DeCorte, 1990; Simon, 1987; Dalton and Hannafin, 1987) that if computers are used this way, they provide powerful educational environments, which encourage pupils to engage in active, exploratative learning. Indeed, National Curriculum legislation is explicit about the need to exploit this aspect of the technology (DES, 1989). It promotes computers as flexible tools to support the development of skills such as evaluation, analysis, hypothesis-testing and problem-solving (ibid.). However, surveys of classroom computer use (DES, 1991; DES, 1991a, DES, 1992; DfE, 1992; DfE, 1993; Ofsted, 1993) suggest that the technology is not being used as educational technologists hoped or as legislation demands.

Most large-scale surveys of classroom computer use are conducted by Her Majesty's Inspectorate of Schools (HMI). In the first year after the IT Capability was implemented (1990-91), HMI inspected around 400 primary schools in England to evaluate their response to the legislation (DES, 1992). They found that although IT was often used successfully as a classroom activity, "most IT work involved the manipulation of text. Pupils had little opportunity for modelling, control work or handling data" (ibid.: 9). In other words, only one aspect of the IT Capability, 'Communicating Information', was being developed in accordance with the legislation. Another inspection two years later (Ofsted, 1993) found that coverage of the IT Capability was getting worse, rather than better:

> Compared with 1990-92, there was more use of IT to reinforce understanding in other subjects such as mathematics and English, but these contributed little to the development of IT capability. There was slightly less data-handling than in 1991-92, and pupils used word processing in only 21 per cent of the lessons compared with 36 per cent last year. There was also less use of LOGO which accounted for 12 per cent of the IT lessons in 1990-91 but only five per cent in 1992-93. Similarly there was less use of IT for other control applications, with computers used to control items such as motors and lights in just five per cent of the IT lessons.
>
> (Para 7, p12)

These HMI reports give no detail about how applications such as word processors and databases are used in classrooms. However, an earlier report (DES, 1991) suggests that they are not always used in ways which develop IT Capability. When HMI inspected primary schools between 1987 and 1989, they found that the potential of word processors was often wasted "as hand-written originals that had been corrected by the teacher were painstakingly copy-typed with little thought for content or style" (ibid.: 7). Moreover, National Curriculum evaluations (e.g., DES, 1992; Ofsted, 1993) only report on computer use which meets legislative requirements. Hence, the recent Ofsted (1993) report gives details of less than half the computer use observed in classrooms. However, a survey of over 600 primary schools (DfE, 1993) conducted during the same period suggests that 'basic practice exercises and puzzles' account for most other computer use.

These reports suggest that computers are failing to deliver expected benefits in classrooms. They are not enhancing the quality of teaching and learning as educational technologists (e.g., Papert, 1980; Chandler, 1984) hoped or as legislation (NCC, 1990) demands. This problem is not unique to education. Industry, commerce and the public sector have all recorded countless examples (e.g., Quintas, 1993) of computer systems which were not used as anticipated, and which failed to deliver expected benefits. Research (e.g., Hughes, Randall and Shapiro, 1992; Heath and Luff, 1992) has begun to suggest why computer systems fail in these other sectors. However, little is known about the cause of 'system failure' in classrooms.

Studies of Classroom Computer Use

Few studies of computer use have been carried out in primary classrooms. Most educational computing research (e.g., Papert, 1980; Dalton and Hannafin, 1987; Middlemas, 1990) focuses on the potential of computers to enhance learning, rather than how this potential transfers in practice to classroom settings. In his review of research on classroom computer use, Benyon (1991) observes that there are "precious few [studies] of any quality or scale. Although there is a huge UK literature on computers/teaching/learning, the vast majority of it can be located in ... the Cognitive Psychology/Artificial Intelligence paradigm ... What is immediately noticeable is ... the conspicuous absence of classroom-based data" (ibid., 277).

Most studies of classroom computer use have been conducted in the USA (e.g., Sheingold, Kane and Endreweit, 1983; Sheingold, Hawkins and Char, 1990; Hawkins et al., 1982) and Canada (e.g., Olson, 1988; Olson, 1992). Studies carried out in the UK have generally been based in secondary rather than primary education (e.g., Bliss, Chandra and Cox, 1986; Chandra, Bliss and Cox, 1988). There have only been two large-scale investigations into computer use in UK primary classrooms.

Both were carried out by Cox and colleagues (Cox, Rhodes and Hall, 1988; Rhodes, 1989; Rhodes and Cox, 1990, Watson, 1993) at Kings College, London. The first study (1985-89) aimed to identify the factors which promoted or inhibited computer use in eight London primary schools, while the second (1989-91) investigated the effect of computer use on learning.

The studies by Cox and colleagues do not present an especially positive picture of computer use in primary classrooms. The first study concluded, "the introduction of computer use has not resulted in major changes in teaching and learning styles as advocated by some of its more avid proponents" (Rhodes and Cox, 1990: 19), while the second study found that in some classes computer use had a slight positive effect on children's reasoning ability in Maths and English (Watson, 1993). The researchers noted, however, that the favourable conditions existing in these classrooms were not common in most primary schools.

Cox and colleagues (Cox, Rhodes and Hall, 1988; Rhodes and Cox, 1990; Watson, 1993) identify a number of factors which result in ineffective computer use, but they particularly highlight issues of technology access, support and training. They emphasize the need for good access to hardware and software, comprehensive teacher training and strong leadership from headteachers and those with special responsibility for computers (Cox, Rhodes and Hall, 1988; Rhodes, 1989; Rhodes and Cox, 1990). While there is no doubt that adequate resources, training and management are essential for successful computer use, studies in other settings (e.g., Heath and Luff, 1992; Hughes, Randall and Shapiro, 1992) suggest that they are not the only important factors: these studies (ibid.) suggest that computer systems must also be sensitive to patterns of social activity in the settings to which they are introduced.

Studies in UK primary schools (e.g., Cox , Rhodes and Hall, 1988; Watson, 1993; Wright, 1987; Heywood and Norman, 1988) pay little attention to the relationship between computer use and social activity. The most recent study by Cox and colleagues (Watson, 1993) focused on learning outcomes, rather than the factors which resulted in particular types of computer use, and most of the data was collected via teacher questionnaires, pupil record sheets and the administration of standard ability tests. In other words, there was little observation of actual classroom computer use. Although their earlier study (Cox, Rhodes and Hall, 1988; Rhodes, 1989; Rhodes and Cox, 1990) focused on computer use rather than learning outcomes, it also relied on questionnaires and interviews: on average, less than three hours was spent observing in each classroom (Rhodes and Cox, 1990).

Although studies by Cox and colleagues (Cox, Rhodes and Hall, 1988; Rhodes, 1989; Rhodes and Cox, 1990; Watson, 1993) identify some of the patterns of computer use that are also identified by this study (such as the use of word processors for copy-typing), these survey-based studies fail to relate patterns of computer use to the social organization of classroom activity. Instead, they explain these patterns in terms of the poor quality of training that teachers receive. For example, Rhodes and Cox (1990: 17) note, "children were frequently observed copy-typing corrected handwritten work onto the computer ... in only one classroom were pupils seen to be encouraged by the teacher to edit for composition or content", but they conclude that this pattern is a result of teachers' failure to discuss the creative use of word processors during IT training.

While studies in UK primary schools (e.g., Cox , Rhodes and Hall, 1988; Watson, 1993; Wright, 1987; Heywood and Norman, 1988) pay little attention to classroom activity, Olson's (1988) study of Canadian elementary schools emphasizes that understanding classroom activity is crucial to understanding computer use. Olson (ibid.) argues that classroom activity is organised around well-established practices or 'routines'. These routines are the 'tools' of classroom management. They allow teachers to control large numbers of children single-handed and direct learning activity. Olson (ibid.: 89) concludes that classroom routines are so important that "they are not what computers will replace, they are where computers must fit if they are to be useful to teachers".

Olson's (ibid.) study suggests that to understand why computers are failing to enhance learning in UK primary schools, it is important to understand classroom practices. Ethnomethodological studies of non-classroom settings (e.g., Suchman, 1983; Suchman and Wynn, 1984) also highlight the need to understand social practices. These studies were the motivation for an ethnographic study of computer use and classroom practices, carried out between June and July, 1991 (Croft, 1992). The study was conducted in a single classroom in a primary school in inner city Manchester. It found evidence to suggest that computer use was, indeed, influenced by classroom practices. Computer use was integrated into classroom activity in ways which preserved existing practices: word processing and basic practice exercises facilitated this process, whereas many other activities required by National Curriculum legislation did not (ibid.).

The research reported here builds on this earlier work. It looks at human-computer interaction in classrooms in more detail, and it expands the previous study to investigate patterns of interaction across classrooms in four different schools. Unlike previous studies of classroom computer use (e.g., Cox , Rhodes and Hall, 1988; Watson, 1993; Wright, 1987; Heywood and Norman, 1988), this study is based on detailed classroom observation. Whereas Rhodes and Cox (1990) spent less than three hours observing in each classroom, I spent an average of 32 hours observing per classroom.

One of the four schools in this study also served as the site of the earlier study, reported in Croft (1992). However, the circumstances of the school had changed since the first study. In February 1993, the school became involved in a scheme to 'raise educational standards' through the use of technology. As a result, it began to receive unprecedented levels of computer equipment, support and training: it became a 'hi tech' primary school. The three other field site schools were also involved in this scheme. In fact, they had become involved in the scheme a year earlier in April 1992. The next section of this chapter discusses this scheme, which is a unique attempt to develop a 'technology-focused' or 'hi-tech' culture in a group of primary schools.

'Hi-tech' classrooms

The Inner City Technology (ICT) project[21] aimed to develop a 'technology focused' culture in a group of fifteen primary schools in inner city Manchester. That is, it aimed to create a multi-media environment, which would foster positive attitudes towards technology and facilitate the implementation of the National Curriculum Technology Order. The Technology Order includes a 'Design and Technology' component as well as the IT Capability (DfE, 1995), and the multi-media environment was to include technologies which would

[21]The name of this project has been changed, as have the names of all the schools, teachers and pupils who participated in this research.

promote both aspects of the order. In other words, it was to include electrical equipment, woodwork tools and art materials as well as computer technology.

The ICT project was funded through the Inner City Grant for Education Support and Training, which awarded funds to schools in 28 LEAs to promote "the raising of standards in inner city schools" (DES, 1992b). The main aim of this scheme was to raise standards in basic skills and 23 of the 28 LEAs received awards to develop literacy programmes. Manchester was the only LEA to receive funds under the scheme to develop Technology education (ibid.), yet like the other authorities, it had bid for funds to develop literacy. However, Manchester LEA was advised by the Department for Education that its bid would be considered more favourably if it were to focus on the development of Technology education in a group of primary schools, which were to feed into a new school; Manchester Technology School.

Manchester Technology School was established under the Technology Schools Initiative (TSI), launched by the Department for Education in 1991 (DfE, 1993). This initiative has its roots in the City Technology College Scheme, launched five years earlier. City Technology Colleges were to offer a 'new choice of school' for urban and inner city areas in the UK (DES, 1986). Backed by industry, they were to foster IT skills as an integral part of a technologically focused and vocationally relevant education (Gerwitz, 1992). However, the scheme did not run smoothly. Industry was slow to come forward with financial support and there were difficulties finding sites (Dale, 1989). Several of the colleges proposed never opened. Manchester City Technology College was one of these colleges (DES, 1986). Manchester Technology School was built in 1993 in place of the college and with a similar mission; to establish a 'computer rich learning environment', which would prepare students to compete successfully in technology based industry.

Although Manchester Technology School is one of many schools in the UK, which offer a technologically based secondary education (DfE, 1993c; DfE, 1994), it is unique in extending this specialist education to its feeder primary schools. The ICT project aims to ensure that pupils who attend Manchester Technology School 'gain maximum advantage' from their specialist education, by preparing them for it during their primary education. To achieve this aim, the project was awarded £1.5 million pounds over three years between April 1992 and April 1995; a sum which represents the equivalent of £100,000 per school and approximately 10 times the average annual computer budget of other UK primary schools (DfE, 1993).[22]

The ICT project presented a unique opportunity to investigate computer use in a group of primary schools with exceptional resources. The schools had access to technologies, training and support services that are far beyond the reach of other schools. Hence, they offered an opportunity to investigate whether the problem of classroom computer use is due to limited resources, as most studies (e.g., Rhodes and Cox, 1990; Watson, 1993) suggest, or whether there is, in fact, a mismatch between the computer uses required by National Curriculum legislation and patterns of social activity in classrooms.

Research Design

This investigation aimed to generate a theoretical explanation of human-computer interaction in a specific group of classrooms, drawn

[22]Approximately two-thirds of ICT project funds were spent on supporting classroom computer use, and in 1992 the average annual expenditure of other primary schools was £2, 250 (DfE, 1993).

from four of the fifteen schools involved in the ICT project. The investigation asked broad questions about the way computers were used; such as why computers were used, when and where they were used, who used them, why certain applications were used rather than others and why these applications were used in particular ways. In order to generate a theoretical explanation which would answer these broad questions, a modified version of the grounded theory method (Glaser and Strauss, 1967; Strauss and Corbin, 1990) was used. Data were collected across a broad range of classroom conditions and analysed using a simplified version of the grounded theory coding procedure (Strauss and Corbin, 1990). The details of this process will be discussed in a later section of this chapter.

The research was informed by an understanding of human-computer interaction, which draws on social constructivism (Pinch and Bijker, 1987; Star and Griesemer, 1989), social worlds theory (Strauss, 1978) and ethnomethodology (Garfinkel, 1967). This understanding comprises a number of basic assumptions; people perceive and interpret computer systems differently in different circumstances, perceptions are 'shared' rather than individual, people's perceptions of and interactions with computer systems may be influenced by perceptions of and interactions with computer systems outside the immediate group and organization in which computer use takes place, and group and organizational boundaries are 'fluid' and 'porous'. This understanding of human-computer interaction required methods of data collection, which were appropriate for its specific combination of assumptions. The methods aimed to investigate perceptions of and interactions with computer systems in classrooms, as well as the influence of factors outside classrooms on these perceptions and interactions.

The remainder of this chapter discusses the methods which were used to collect and analyse data during the investigation. Although the methods are described as if they had been developed prior to the start of the investigation, they evolved during the investigation. They altered in response to the changing circumstances of the research situation and the emerging understanding of the research phenomenon.

The Field Sites

Data were collected from four schools involved in the ICT project; Range primary school, St Catherine's primary school, Priory Lane primary school and Clement Infant school. The schools are located in an area of inner city Manchester, where housing is poor, unemployment is high and up to 60% of families receive income support. It is an ethnically mixed area with a high proportion of Afro-Caribbean and Asian families. Some pupils require English language support at school, and many have behavioural difficulties.

The four field site schools were selected for a mixture of pragmatic and methodological reasons. Range primary school was the site of an earlier study by the author in June/July, 1992. Consequently, it formed an obvious starting point when fieldwork towards the current study began in November 1992. Shortly after fieldwork towards this study began, Range primary school became involved in the ICT project. Through the Head of Range, I made contact with the Manager of this project and the other schools involved.[23] On visiting these schools, it

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[23]The first person pronoun is used frequently in this chapter and the following chapter. Although the use of the first person pronoun is not common in conventional academic texts, it is usual in ethnographic texts, because of the role played by the ethnographer in research: The ethnographer is, to a significant extent, the 'research tool' and findings are influenced by interaction between the ethnographer and research participants (Hammersley, 1992).

became evident that the investigation would benefit if it was expanded to include some of them.[24]

By collecting data in four schools, rather than a single school, I was able to investigate computer use in a wider range of conditions than would otherwise have been possible. Each school offered the chance to investigate a unique and interesting set of circumstances. Priory Lane primary school was introducing a new model of computer into several classrooms, Clement infant school had introduced industry-standard, rather than 'Acorn', computers and had made particular progress in computer use in its nursery, while St Catherine's primary school was the test site for many new technologies trialed by the project (such as laptop computers, CD-Roms and touch screens).[25] St Catherine's primary school was also the administration base for the ICT project and its Head served as Project Manager.

The four field site schools are not represented equally in this investigation. The aim of the investigation was not to perform a comparative analysis across schools, but to develop a comprehensive understanding of the phenomenon of classroom computer use: the varied conditions in the schools were used as a 'map of the territory' of this phenomenon (Zuboff, 1988), and the investigation was expanded to include different classrooms as new questions and opportunities arose. In total, I visited eleven classrooms in four schools: three upper junior classes (age range 10- 11), six infant classes (age range 6-7) and two nurseries (age range 3-5). These classrooms were selected not only because of their particular circumstances, but also because teachers and pupils were comfortable with my presence.

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[24]The negotiation of access to fieldsites is discussed in more detail in a later section of this chapter.

[25]More details about these technologies are given in the next chapter.

Data collection

The main investigation took place over a period of 21 months between November 1992 and July 1994. However, some data were collected during an earlier study of an infant classroom at Range primary school between June and July, 1992. The investigation involved approximately 360 hours of classroom observation (12 of which were videotaped), 10 hours of teacher interviews and 20 hours of pupil interviews. Interviews were also conducted with the headteachers of the field site schools, ICT project staff,[26] the IT adviser for Manchester LEA and a representative of the 'Inner Cities' team at the Department for Education.[27] In addition, documents pertaining to school, LEA and National educational computing policy were examined.

Data were collected outside as well as inside classrooms in order to understand the wider arena in which classrooms are located. According to social worlds theory (Strauss, 1978; Strauss, 1982), no organization can be considered in isolation. Organizations are situated in 'arenas' of multiple social worlds, in which they interact with other organizations. Moreover, individual organizations can themselves be viewed as arenas: they are composed of members of multiple social worlds and sub-worlds, who have varied aims and alliances (Strauss, 1978). Hence, classrooms can be viewed as existing in wider educational and political worlds composed of schools, LEAs, the National education system and, in this case, the ICT project administration. However, classrooms also intersect with other worlds; such as the professional world of 'teaching' and the various domestic and leisure worlds, to which pupils and teachers belong outside classrooms. Activity inside individual

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[26]A formal, semi-structured interview was conducted with the Manger of the project. In addition, I had numerous conversations with the technology support teachers, technology ancilliary workers and technicians who worked in the field site schools.
[27]This interview was conducted by telephone.

classrooms is influenced by activity in this wider arena of multiple social worlds.

Data about the ICT project, Manchester LEA and the National education system were collected from policy documents and interviews. However, data collection in schools also involved participation in a variety of activities outside the classroom. I attended school assemblies, parents evenings, open days, sports days, school trips, staff meetings and teacher training days. These activities are an important part of school life, and they provide an opportunity to capture interactions which take place in the wider arena in which classrooms are located. For example, at school assemblies and staff meetings, different sub-worlds in schools interact. While interactions within these sub-worlds could be observed directly, interactions at the intersection of social worlds, such as interactions between pupils and parents or teachers and parents, were particularly difficult to capture.

In order to work within the constraints of the research situation, a multi-faceted investigation was conducted: that is, no limits were placed on techniques of data collection or the types of data acquired (Glaser and Strauss, 1967). Techniques were used which would best obtain the data needed within existing constraints. Hence, much of the data about interactions between social worlds, such as that between pupils and parents or teachers and parents, were gathered indirectly through interviews with pupils and teachers or through documents (e.g., letters, reports and schoolwork sent to parents).

The production and use of documents proved to be an integral feature of classroom life, and they formed an important source of data. Most classroom activity takes place behind closed doors, and documents such as exercise books and worksheets provide tangible evidence of the 'work' which takes place there. Documents on public display are particularly significant; classroom walls are covered with displays of pupils' work, information about significant events and records of pupil achievements and behaviour (see Appendix B for a photograph of one classroom).

Although a range of techniques were used to gather information during the investigation, the vast majority of data were collected through observation, or rather participation, in classrooms. In order to understand people's interactions with and perceptions of computers in classrooms, I had to understand classroom life. In order to understand classroom life, I had to spend time in classrooms, and in order to spend time in classrooms, I had to participate in activity there.

Participant observation in classrooms

Gold (1970) identifies four types of participation in fieldwork, ranging from 'complete participation', in which the researcher goes 'under cover' and becomes a full group member to 'complete observation', in which the researcher is a 'fly on the wall' observer, who refrains from interaction with informants. Gold (1970) suggests that researchers simply select whichever role they feel most comfortable with. However, Olesen and Whittaker (1970) argue that field roles are not selected, but made or negotiated. They argue that the process of 'role-making' involves both the researcher and research participants. Moreover, they observe that the range of roles open to researchers depends to an extent on the roles which are already available in a setting.

A limited number of roles exist in the classroom setting. Classrooms usually contain between 20 and 40 children and one adult; the teacher.

In addition, parents or nursery nurses sometimes act as classroom assistants, listening to children read and helping them with special projects. Inspectors or educational psychologists may visit classrooms for short periods of time as non-participant observers, but other visitors to classrooms participate. Although it was my intention to participate as little as possible in activity in classrooms, so as not to disturb the normal flow of events, I was soon 'drawn into participation'. In fact, I entered into a commitment to participate before the research began.

Gaining access to research sites is a notoriously difficult process (Hammersley and Atkinson, 1990). Gaining access to classrooms is particularly difficult. I not only had to gain permission to observe an activity which is usually conducted behind closed doors, but also had to convince teachers that I could be trusted to work in close proximity with young children. My initial contact with Range primary school was facilitated by a 'middle man', a retired schools inspector who had known the Headteacher for many years.[28] He suggested that I offer some reciprocal benefit in exchange for access to classrooms, so during my initial meeting with the Headteacher, I informed her that I was interested in studying computer use and suggested that the school might benefit through a report on computer use and perhaps some suggestions for improvements. The Headteacher replied, however, that she thought teachers would rather have practical help in the classroom. Subsequent requests to Headteachers and classroom teachers in other schools met

[28]'Middle men' facilitated access to all schools. Permission to conduct research in schools involved in the ICT project was initially refused by the Project Manager on the grounds that the high profile nature of the project had attracted many similar requests. Access was only granted after the Headteacher of Range intervened on my behalf. The Project Manager (and Headteacher of St Catherine's primary school) subsequently acted as 'middle man' for Priory Lane and St Clements primary schools.

with a similar response:[29] Teachers would be happy to have 'help' in their classrooms.

The type of 'help' which teachers most wanted in their classrooms was help with computer use. When I informed teachers that I was interested in computer use,[30] I was asked to assist in the activity in a number of ways; by adding graphics to work for classroom displays, by helping small groups of pupils to use control technology (such as LOGO turtles), by making simple instruction cards to assist pupils in the use of particular packages and, most often, by simply assisting pupils with the use of word processors and other packages commonly used in classrooms. By assisting in these activities, I intervened in the research phenomenon to a much greater extent than would be expected in traditional ethnography.

Ethnography is often regarded as "the study of situations that would have occurred naturally without the ethnographer's presence" (Hammersley, 1992: 163). Indeed, the ability of the method to get to the bottom of 'what's really going on' in a setting is seen as its main advantage. Yet ethnographers cannot investigate the 'natural' world without being part of it (Atkinson and Hammersley, 1994), and despite their best attempts to minimise their effects on the situation, the effects may be significant (Hammersley, 1992). Indeed, during the two months that I spent in a classroom at Range primary school, my influence on events was so significant that a marked change in computer use took place (Croft, 1992). Although this influence was unintended, it was not necessarily detrimental.

[29]Permission to enter classrooms was gained initially from Headteachers, then from individual classroom teachers.

[30]All teachers were made aware of my interest in computer use and conveyed this interest to pupils.

Hammersley and Atkinson (1990) argue that interaction between ethnographers and research phenomena can benefit an investigation. They observe that "by systematically modifying one's role in the field, different kinds of data can be collected whose comparison may greatly enhance interpretation of the social processes under study", and they argue that ethnographers should recognise and control their influence on research findings, rather than attempt to eliminate it (ibid.). Glaser and Strauss (1967) go one step further and argue that ethnographers should actually control events to develop a more comprehensive theory. They argue that if ongoing events do not provide theoretically relevant data, ethnographers should be prepared to manipulate events in order to see what will happen (ibid.).

I allowed for the effects that I had on classroom computer use by varying my participation in classroom activities. Instead of intervening directly in computer use, I listened to pupils read or helped with spelling and maths queries. Pupils involved me naturally in these activities. They approached me for help as they would a parent or other classroom 'helper'. Indeed, whatever my participation in classroom activities, both teachers and pupils made it clear that they regarded me as a 'responsible adult'. Teachers introduced me to pupils as "Miss Croft" and pupils addressed me simply as "Miss". If teachers left the room, pupils 'tested' my control of the class as they might test a student teacher. The noise level rose, pupils began to move around the room and I would be 'challenged' to restore order. I was initially very uncomfortable about these interactions: they impeded my efforts to assume a 'neutral' role. However, the significance of the roles and activities that I was drawn into became clearer as the investigation progressed, and they became an important source of data.

Data collection in classrooms

As I participated in classroom activity, I gathered data through observation and casual conversation. I gathered data about general classroom events, as well as data about people's interactions with and perceptions of computer systems.[31] When I assisted pupils in computer activity, I talked to them about what they were doing and why they were doing it. When I participated in other activity, I used the opportunity to observe interaction at the computer. During these observations, I was particularly concerned to capture interaction between different groups in the classroom; that is, between computer users and the teacher, as well as between computer users and the other pupils. The aim was to explicate the relationship between computer activity and other activity in the classroom. In order to capture the flow of activity, I observed at different times of the school day, week and year.

Data about classroom activity were not only gathered through direct observation of interactions, but also from the physical organisation and appearance of classrooms (see Appendix C for a plan of one classroom). The arrangement of desks embodied information about classroom discipline; 'problem' pupils were often seated alone at tables facing the wall, next to the teachers desk. The location of computer equipment was also significant; in some classrooms computers were placed in a central location, near to the teacher's desk, while in others they were placed outside the main classroom area. Moreover, some classrooms had dedicated 'computer areas' with large displays of computer work, while others gave more emphasis to areas for other

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[31] Although the ICT Project aimed to promote the use of a range of technologies, the investigation focused specifically on the use of computer technology.

activity, such as 'art' or 'craftwork' (see Appendix B for a photograph of one classroom with a dedicated 'computer area').

I recorded observations about classroom activity in a diary, although it was often difficult to do this as events occurred. If I took notes openly in the classroom, pupils asked what I was writing about, while teachers joked nervously about my opinion of their teaching abilities.[32] I therefore jotted down keywords as events occurred and left the classroom to take lengthier notes. I also wrote up fieldnotes each evening. In order to investigate specific aspects of computer activity (e.g., the number and type of teacher interventions in an activity over a period of time), I used schemas to record particular observations. In addition, I recorded around 12 hours of classroom activity on videotape. I had intended to record more observations this way, but the data proved difficult both to collect and analyse.[33] I therefore recorded only those interactions which were particularly difficult to understand or for which a permanent record was needed (e.g., the introduction of a new piece of technology to a classroom).

In order to explicate the relationship between interactions with computers and perceptions of computers, I focused on language. Perceptions or meanings are difficult to explicate: they cannot be observed in the same way as action. Most sociological approaches to meaning and action (e.g., ethnomethodology and symbolic interactionism) access meaning through language (Cuff, Sharrock and Francis, 1990). They view language as the primary (though not the

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[32]Hammersley and Atkinson (1990) note that teachers are particularly wary of the motives of researchers.

[33]In order to capture computer activity in the context of other classroom activity, a microphone had to be set up next to the computer, while the camera was at a considerable distance. This led to problems with sound quality. Moreover, pupils 'played up to the camera' to such an extent that it was impossible to collect meaningful data unless the equipment was hidden. Data analysis proved even more time-consuming, because there was no computer support available.

only) medium through which meaning is conveyed. I therefore explicated people's perceptions of computers by analysing their talk about computers. I 'eavesdropped' on conversations which occurred naturally between teachers and pupils. However, since these conversations were infrequent, I also engineered conversations about computers.

I talked to teachers and pupils about what they did with computers, how they did it, when they did it and why. These exchanges were based on observations of computer use. I used the exchanges to follow up significant incidents and to explore participants' understandings of their interactions. The aim was not to construct an objective representation of the circumstances which resulted in specific interactions, but to explicate how teachers and pupils perceived the circumstances. During the exchanges, I listened carefully to the way that teachers and pupils talked about computers and paid particular attention to the language that they used. When patterns emerged, I followed them up in conversations with other teachers and pupils in order to determine whether perceptions or meanings were 'shared'.

In addition to these casual conversations, I conducted a series of formal interviews during the latter stages of the research. These interviews explored specific research themes in greater depth, and they provided a chance to cross-check interpretations and hypotheses (see Appendix F for the semi-structured interview schedules used during these interviews). I interviewed 10 of the 11 teachers who participated in the research and pupils from 7 of the 11 classes.[34] Between 8 and 10 pupils were interviewed from each class, with roughly equal numbers of male

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[34]One teacher could not be interviewed because she was on sick leave, and it proved impossible to collect meaningful data from pupils in the two nursery classes. Pupils from the remaining two classes were excluded, because sufficient data had already been collected and there was nothing to be gained from the exercise.

and female interviewees. Teacher interviews lasted between 30 and 45 minutes, while pupil interviews lasted 20 to 30 minutes. All the interviews were tape-recorded. The teacher interviews were then transcribed completely, as were half the pupil interviews. Once a coding scheme had been finalised, relevant sections of the remaining pupil interviews were transcribed.

Throughout data collection, I followed the grounded theory principle of 'theoretical sampling'; that is, data collection was controlled by the emerging theory (Strauss and Corbin, 1990). At the start of the investigation, the aim was to uncover as many different aspects of the phenomenon of classroom computer use as possible. I wrote down almost everything that I observed and heard in relatively unstructured fieldnotes. However, as patterns began to appear, data gathering became more focused. It was guided by the concepts, gaps and questions which emerged during analysis. I developed concepts by gathering data about their properties under different conditions, and as hypotheses emerged, I looked for data which bore specifically on these relationships. Hence, observation and conversation in classrooms became more focused as the investigation progressed.

Data analysis

Data analysis took place throughout the investigation. It began as soon as the first data were collected and continued long after the final data were collected. The basic analytic operation was one of 'constant comparison'; that is, incidents and events were compared for their similarities and differences (Glaser and Strauss, 1967). This operation lies at the heart of the grounded theory method. When grounded theory was first introduced, constant comparison was a general technique, a way of thinking about data rather than a well established procedure (ibid.). However, in recent years this procedure has been developed into an elaborate coding scheme (Strauss and Corbin, 1990).

The grounded theory coding scheme consists of three distinct phases; open, axial and selective coding (ibid.). The first stage is open coding, during which similar incidents and events are grouped to form categories; the second is axial coding, when categories are developed and hypotheses are formulated; and the final stage is selective coding, when a single 'core' category is selected and systematically related to all other categories. In addition to these coding procedures, two other operations are necessary in order to achieve a fully integrated grounded theory; the conditions and consequences of events must be traced using an analytic tool known as the 'conditional matrix' and 'process' must be added to the theory to demonstrate how events evolve over time (ibid.).

Although the function of these coding schemes and tools is relatively straightforward, their execution is difficult to achieve in practice. Some operations lack well-defined procedures. For example, 'process' is "an elusive term, one that is not easily explained. It does not necessarily stand out as such in data. Nor does its discovery entail a specific set of procedures ... One knows it is there, feels its presence as changed action/interaction, even though one can't actually see it as such" (Strauss and Corbin, 1990: 144). Other operations are so complex that "the analyst may get lost in coding and category schemes" (Denzin, 1994: 508). For example, the process of axial coding contains four distinct analytic steps; the conditional matrix traces the conditions and consequences of actions through eight different levels of influence (ranging from 'individual' to 'international'); and theory development is recorded in four different types of memos, as well as two different types of diagrams (Strauss and Corbin, 1990).

Grounded theory coding procedures are not only problematic to execute: they could also impose an inappropriate structure on findings. The coding process results in a theoretical formulation, which takes the shape of a tree structure (ibid.). At the top of the tree is the central concept or 'core' category, which 'glues' the theory together. This core category branches out into a number of main categories, and the main categories are themselves composed of numerous sub-categories. Categories are increasingly abstract towards the top of the tree and closer to actual data towards the bottom of the tree (ibid.) However, data may not fit a hierarchical structure, in which each entity is an instance of another more abstract entity: multiplicity in the data may demand a different type of structure.

Due to the rigidness and complexity of grounded theory coding procedures, they were not followed to the letter. Instead, the procedures were used as 'heuristics': data were analysed using the general method of constant comparison (Glaser and Strauss, 1967), but specific procedures for different types of coding were not followed. The conditions and consequences of interactions were traced through different levels of influence, but they were traced through the levels relevant to this investigation (the worlds and sub-worlds with which classrooms intersect and interact), rather than the levels specified in the conditional matrix (Strauss and Corbin, 1990)

At the start of the investigation, data were analysed by simply sifting through fieldnotes. I read and re-read the notes, looking for interesting patterns and puzzling or surprising phenomena. During this process, I made notes about questions and concepts suggested by the data. Concepts were often suggested by the language that teachers and pupils used to describe computer activity. When unusual terms and phrases occurred repeatedly, they were taken as evidence of phenomena which should be investigated further (Hammersley and Atkinson, 1990). Once several basic concepts had emerged, I developed a simple coding scheme, which was used to code all fieldnotes. This coding process generated more questions, which guided a second phase of data collection. During this phase, concepts were developed and related to each other. Fieldnotes were then re-coded using a more sophisticated coding scheme. The concepts were finally structured to form a theory by re-coding the data after a third phase of data collection.[35]

During analysis, I shared observations and inferences about the data with pupils, teachers and other staff involved in the ICT project. The process of sharing inferences with research participants is often referred to as 'respondent validation' (e.g., Hammersley and Atkinson, 1990). It is regarded by some ethnographers (e.g., Sackmann, 1991; Blease and Cohen, 1990) as a means of validating interpretations by testing whether they correspond with those of research participants. For example, Sackmann (1991: 195) claims that she was able to "confirm the accuracy and comprehensiveness" of findings this way. However, Hammersley and Atkinson (1990) counsel caution with regard to respondent validation. They argue (ibid.: 196), "we cannot assume that [participants] are consciously aware of the decision rules that they use, or even that, they can recognize them when someone documents them". In this investigation, observations were shared with participants in order to gather data about other relevant thoughts and events, not as a means of validating interpretations.

[35]Data analysis was to be aided by NUDIST, a qualitative analysis package which supports the grounded theory method (Richards and Richards, 1994). However, the use of this package was abandoned in favour of 'pencil and paper' techniques, because of its tendency to impose a rigid, hierarchical structure on data.

'Respondent validation' was inappropriate in this investigation for another reason; the need to maintain a stance of 'analytic scepticism' (Cooper et al., 1995). The previous chapter emphasized that boundaries (such as group and organizational boundaries), dichotomies (such as that between the 'technical' and the 'social') and familiar concepts (such as the 'user' and the 'interface') should be treated sceptically. However, analytic scepticism is difficult to achieve in practice (Hammersley and Atkinson, 1990). It demands the ability to treat research phenomena as if they were strange and exotic. For anthropologists studying remote communities, research phenomena are strange and exotic. However, in settings that are more familiar, ethnographers have to work at making the familiar strange.

In order to render everyday classroom activity 'anthropologically strange', I practised grounded theory techniques for developing 'theoretical sensitivity' (Strauss and Corbin, 1990). Theoretical sensitivity is the ability to look beneath the obvious in data (ibid.). Strauss and Corbin (ibid.) developed a set of mental exercises to aid the process. Each exercise encourages researchers to look at phenomena in new and different ways. For example, the 'flip flop' technique turns concepts upside down: in order to understand classroom control, I would imagine a classroom where there was no control.[36] 'Close-in' comparisons compare similar situations (such as an infant classroom and a nursery classroom), while 'far-out' comparisons compare situations which have little in common (such as a classroom and an office). Both types of comparison aim to shed light on a situation by revealing what it does or does not have in common with another situation.

[36]Garfinkel (1967) recommends a similar exercise. He suggests that researchers "take a familiar scene and ask what can be done to make trouble" (ibid.: 37).

Data analysis was also enhanced by reading relevant literature. I not only read studies of classroom computer use (e.g., Olson, 1988; Blease and Cohen, 1990), but also studies of general classroom activity (e.g., Nias, 1989; Olson, 1992) and studies of activity in other real world settings (e.g., Heath and Luff, 1992; Suchman, 1983). Comparative reading plays a valuable role in theory generation (Strauss and Corbin, 1990; Hammersley and Atkinson, 1990). The comparison of data with findings from other classrooms facilitated an understanding of the relationship between computer use and classroom activity, while comparison with studies of other real world settings suggested the extent to which observed phenomena were also relevant to understanding human-computer interaction in non-classroom settings. The findings of other studies are referenced where appropriate in the following chapters of the thesis.

The next two chapters of the thesis present the findings and implications of the investigation: chapter 4 describes how computers were used in the field site classrooms and presents a theory of this computer use, while chapter 5 considers the implications of the theory for the concepts and methods which are used to understand human-computer interaction.

Chapter 4: A Theory of Classroom Computer Use

Introduction

This chapter describes how computers were used in the field site classrooms, and it presents a theory of this computer use. The description of computer use identifies patterns in data collected from eleven different classrooms in four different schools. The theory of computer use draws upon concepts and conceptual relationships to explain these patterns.

Computers were used in the field site classrooms in 'unexpected' ways. They were not used for LOGO programming, control work or database work, but for copy-typing, basic practice exercises and adventure games. Pupils did not have 'free' access to computers. Instead, teachers decided when pupils should use computers and how they should use them. Moreover, teachers gave some pupils more access to computers than others. This theory aims to explain these patterns of computer use. This theory draws on the concept of 'interpretive flexibility' (Pinch and Bijker, 1987) to argue that computers were used in unexpected ways, because they were perceived or interpreted within the specific social, technical and physical circumstances which existed[37] in classrooms. This theory also argues that classroom computer use was influenced not only by circumstances inside classrooms, but by interpretations of computer use which arose outside classrooms.

This theory of computer use differs from the theoretical models which are usually constructed in the computer sciences. While these models

[37]The term 'exist' is used here in a weak sense. It is not meant to imply the literal, objective existence of either phenomena or circumstances.

tend to describe phenomena in terms of finite sets of variables (Winograd and Flores, 1987), classroom computer use does not lend itself to such description. The phenomenon of classroom computer use occurs within a complex socio-technical system. The system is open; it cannot be modelled as a complete set of variables, which are isolated from the rest of the world. The system is also dynamic; its parts and properties change over time.

This theory explains the existence of particular patterns of classroom computer use, and it provides a basis for developing strategies to improve computer use. However, the theory does not provide a basis for accurately predicting the effects of particular strategies. It is impossible to generate reliable predictions about the effects of specific interventions in computer use for the following reasons. Firstly, the theory does not identify all the conditions which resulted in the particular computer use observed in classrooms. Instead, it identifies a number of elements within the socio-technical system which are central to the existence of the phenomenon. Secondly, elements of this socio-technical system are interdependent: A change in one part of the system may produce unforeseen changes in other parts of the system. This theory aims to understand the complexity of classroom computer use, and it does not reduce this complexity in the interests of developing a model with immediate practical application.

This chapter is divided into two main sections. The first section describes the patterns observed in classroom computer use and introduces concepts which explain them. This section is deliberately narrative in style: it builds a detailed picture of computer use in terms of the organisation of classroom activity, and it introduces concepts which are grounded in observations of this activity. The second section draws these concepts together into a coherent theoretical framework.

Patterns and perceptions of computers in classrooms

This section describes patterns of computer use in the field site classrooms. It discusses who used computers, why they used them, when they used them and what they did with them. It describes the use of computers for word processing, basic practice exercises and games; the use of word processors to copy-type previously hand-written work; how teachers controlled access to computers and how teachers ensured that computing was an unsupervised activity. Since other accounts of classroom computer use (e.g., Cox, Rhodes and Hall, 1988; Rhodes and Cox, 1990) suggest that ineffective use of the technology is the result of inadequate resources and support, this section also describes the equipment, training and support that were available for computer use.

This section introduces explanatory concepts which are grounded both in interpretations of computers and the circumstances in which they were interpreted. Computers were interpreted as 'artefacts for unsupervised use' (substitute teachers), as 'fillers' and 'rewards', and as artefacts for 'work', 'messing around' and 'play'. These interpretations arose in technical circumstances which included a hardware distribution of 'one computer per classroom', physical circumstances which included the 'closed' classroom organisation of schooling (where evidence of 'work' was important) and social circumstances which demanded that teachers 'maximise effective learning', 'retain classroom control' and maintain their status as 'experts'.

This section begins with a discussion of the technical circumstances in which computers were interpreted; the hardware distribution of 'one computer per classroom'.

One computer per classroom

In the field site schools, computers were not placed in central laboratories, as is common in UK secondary schools (DfE, 1993). Instead, they were placed in individual classrooms. Most classrooms had just one computer, although two infant classrooms each had two computers; Mrs Wilson's class in Priory Lane primary school and Mr Andrews class in Range primary school.[38] A hardware distribution of just one computer per classroom computer is usual in UK primary schools (DfE, 1993; Watson, 1993). Indeed, many classrooms do not yet have their own computer and have to share machines with other classrooms (DfE, 1993). The field site classrooms each had a computer placed permanently in the classroom and, in this respect, they were well equipped.

The reasons for this hardware distribution were difficult to discern. It was not possible to identify when, or indeed, if a decision had been taken to place computers in individual classrooms rather than in a central location. Instead, this distribution pattern seemed to be the result of a combination of circumstances; the way in which schools had originally acquired computers, LEA policy designed to bring about effective use of computers and a belief within schools that 'things could not be otherwise'.

Like many other UK primary schools (Bleach, 1986), the field site schools acquired their first computers in the early 1980s through the Department for Trade and Industry's 'Micros in Schools' scheme. The 'Micros in Schools' scheme offered schools a 50% subsidy on the purchase of their first computer (Boyd-Barrett, 1990). Each of the

[38]The names of all teachers, pupils and schools in this study have been changed to protect participant confidentiality.

field site schools acquired a single computer under this scheme, and over the next 10 years, they acquired other computers through successive government-funded hardware schemes. However, these computers were acquired in ones and twos, and for many years the schools did not have enough computers to 'group' them in a central area.

As schools acquired computers, Manchester Local Education Authority (LEA) drafted an IT policy for primary schools. This policy states explicitly that "machines should be based in classrooms". The LEA IT advisor explained during an interview that the Authority viewed computer laboratories as "an artificial learning environment", and that by making computers "part of the normal classroom environment", they hoped to encourage the use of the computer as a general tool alongside other resources.

Teachers in the field site classrooms had never used a computer laboratory, but they were asked in interviews how they felt about the idea. Most teachers viewed the idea negatively. However, unlike the LEA, teachers did not object to the idea of a computer laboratory for educational reasons. Rather, their concerns were of a more practical nature. For example, Mrs Wilson, an infant teacher at Priory Lane primary school commented "it would probably be far more hair raising [in a laboratory] because they'd all be sort of pressing buttons at once and you couldn't be in enough places at the same time", while another infant teacher at the school thought that "it probably wouldn't work for this age group because they get stuck so often ... you have to sit with them while they do it" and Ms Williams, the nursery teacher at Clement infant school thought that "you'd be just ... shouting at them in the end ... you'd be going like sit there, no you can't get up, no sit down there ... it would just be management all the time. You wouldn't be able to get anything done".

Teacher concerns about classroom management are a constant theme in this account. They influenced almost every aspect of computer use, including the location of machines within classrooms. Most computers were located in the main classroom area, but some were placed in alcoves just off the main classroom. Mr Holland placed his computer in an alcove, so that it was "away from everybody because it's so disruptive". Mrs Wilson also placed one of her two computers in an alcove "because of the noise". Both teachers felt that noise during computer activity distracted pupils nearby. However, two other teachers moved computers out of alcoves back to the main classroom for a different reason. Ms Jennings, an infant teacher at Priory Lane primary school explained,"[the computer] used to be [in the alcove] but everytime somebody got stuck then I had to go in there and once you're in there you can't see what's going on in [the main classroom]". Indeed, most teachers placed the computer in a central location, which could be monitored from elsewhere in the classroom and from which they could monitor other parts of the classroom (see Appendix C for a plan illustrating a typical central location). The significance of noise and classroom control are developed in later sections of this chapter. The intention here is simply to illustrate some of the factors which influenced the location of computers.

Although most classrooms had only one computer, the schools actually had enough machines for each classroom to have two computers. All the classrooms had a new machine from the Acorn range (the Archimedes, A3000 or A4000), with the exception of Ms Prior's classroom at Clement infant school, which had an IBM-compatible computer.[39] Teachers also had the option of keeping an older machine from the Acorn range in their classrooms; the BBC Acorn B or the Acorn Master. These machines are the most common in UK primary classrooms, and unlike newer Acorn models, they have no internal hard drive, no mouse and often only a monochrome monitor (DfE, 1993). Only Mr Andrews at Range primary school and Mrs Wilson at Priory Lane chose to keep one of these machines in their classroom.

Teachers and pupils viewed these older computers differently to the more recent models. They were perceived to have less value and were often referred to in conversation as "just a BBC". Ms Kerr at St Catherine's primary school found these computers "a bit boring really ... you know it was like get somebody to write on the computer just because it was there", while Ms Jennings at Priory Lane "wasn't so bothered about the BBC ... but we've had these new Archimedes ones and ... it makes it a lot nicer the actual things that you can produce on it". The newer Acorn models were seen as more exciting and they facilitated new modes of computer use. In the nursery at Clement infant school, teachers "didn't use the BBC in the same way as the Archimedes ... we didn't just leave it out for [pupils] to work on their own". Once teachers had a new computer in their classroom, few had any interest in retaining one of the older models. Hence, most classrooms had only one computer.

A hardware distribution of 'one computer per classroom' is common to most UK primary schools (DfE, 1993; Watson, 1993). In the field site schools, this distribution of computers was not the result of a single,

[39]Over 70% of computers in UK primary schools are made by Acorn. Less than 1% of machines are IBM or IBM-compatible PCs (DfE, 1993).Government funding, LEA software provision, training and technical support are all tied to the purchase of computers from two British companies, Acorn and Research Machines (Boyd-Barrett, 1990, Wellington et al., 1988). Most schools involved in the ICT project followed this purchasing policy. Only Clement infant school bought a limited number of IBM-compatible machines.

conscious decision: it evolved over a number of years within a specific set of circumstances. Yet this hardware distribution had a powerful influence on classroom computer use, as later sections of this chapter demonstrate.

The following section of this chapter discusses the computer resources, support and training available in the field site schools. Previous studies of UK primary schools (Cox, Rhodes and Hall, 1988; Rhodes and Cox, 1990; Watson, 1993) paint a gloomy picture of computer use, and they account for this computer use in terms of inadequate resources, support and training. However, the schools in this study were among the best equipped and supported primary schools in the country, due to their involvement in the ICT project.

Computer equipment, training and support

The ICT project spent almost a million pounds equipping schools with hardware and software, training teachers and providing support for computer use. As a result, the field site schools were far better equipped than most other UK primary schools. While classrooms in other schools often have to share printers (DfE, 1993), the field site classrooms each had their own printer. Most printers were monochrome dot matrix machines, but four of the classrooms also had inkjet colour printers, a scarce resource in primary schools (DfE, 1993).[40] Classrooms had access to a range of peripheral devices including control technology (such as robots and programmable turtles) electronic sensors (which measure physical quantities such as temperature and pressure), and alternative input devices such as

[40]Printers were connected up to individual machines, because none of the computers were networked. Only 2% of computers in UK primary schools are networked (DfE, 1993). The ICT project experimented with networking in two of the four field site schools. However, this development took place once field work had finished.

overlay keyboards (which can be programmed to give an alphabetic keyboard arrangement or to associate words with pictures) and touch screens. In addition, certain schools had access to other technologies on a 'trial' basis. St Catherine's primary school trialed CD-ROM technology and Clement infant school trialed palmtop computers, while both schools experimented with computerized spelling aids. Although most schools have concept keyboards and control technology, few have access to these other technologies (DfE, 1993).

Each of the field site classrooms had a wide range of software. This included word processing packages, desk top publishing applications, graphics packages, art packages, sorting and matching programs, LOGO,[41] data bases, control applications, practice exercises[42] and adventure games.[43] Most of this software was provided by Manchester LEA, which gives all local schools a core set of software to meet the needs of the National Curriculum.[44] All infant and junior classrooms had access to the full range of applications. However, software in the nursery classes was limited to simple sorting and matching games.

The use of this equipment was supported by ICT project staff. Each school had a full-time technology ancillary and a part-time technology teacher.[45] Ancillaries and technology teachers worked alongside

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[41] LOGO is a programming language developed by Papert (1980) and colleagues for young children. Based on a Piagetian view of learning, this application uses programming as a vehicle for developing problem-solving skills. Pupils use simple instructions to create graphics patterns on screen or to control a floor robot.

[42]Practice exercises are 'drill and practice' programs, which reinforce basic skills in spelling, word recognition and mathematics.

[43]Adventure games are problem-solving programs, which are based around stories about rescuing princesses, finding treasure and fighting giants. Pupils become participants in the story and have to respond to challenges and puzzles, based around language or mathematics exercises. For example, in the popular adventure game 'Granny's Garden', pupils have to find and rescue a group off princes and princesses who have been kidnapped by a wicked witch.

[44]LEA computer centres supply most of the software in UK primary schools (DfE, 1993).

[45]The ancilliaries were not fully qualified teachers. Two of the ancilliaries had computing backgrounds and some childcare experience, the others had nursery

classroom teachers, assisting in computer activities and training teachers and pupils in the use of equipment. In addition, schools were visited each week by technicians, who maintained and repaired equipment. Most UK primary schools receive no outside support for computer use (DfE, 1993).

Teachers received computer training from a variety of sources. Most gained little computer experience during initial teacher training,[46] although all had attended several days in-service training (INSET) prior to the start of the ICT project. During the project, teachers received most of their training from technology teachers and ancillaries. Project staff were given intensive training,[47] which they 'cascaded' through schools. This happened in a number of ways; technology teachers and ancillaries worked alongside teachers in classrooms, ran 'whole school' INSET courses and gave one to one tuition to teachers both during school hours and in the evenings.

Despite exceptional levels of computer resources, support and training, computer use in these schools met neither the demands of National Curriculum legislation (DES, 1989), nor the expectations of educational technologists (Papert, 1980; Chandler, 1984). In fact, patterns of computer use in these classrooms are very similar to patterns emerging from surveys of computer use in other classrooms (DES, 1991; DES, 1992; DfE, 1993). The following section of this chapter describes this computer use.

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nursing qualifications and no computing background. The technology teachers were all qualified teachers with prior computer experience.

[46]Few student teachers have regular access to computers during initial teacher training (Rhodes and Cox, 1990).

[47]Technology teachers attended INSET for a day a week over a 2 year period; approximately half these training sessions focused on the use of computer technology. Teachers were generally satisfied with their computer-related INSET. However, ancilliaries were less content with the quality and quantity of their training, which took place over only a few days. This lack of training was offset in two field site schools by the extensive prior experience of ancilliaries.

Computing for word processing, basic practice and games

Although the field site schools had access to a wide range of 'new' technologies such as CD-ROM palmtop computers and computerized spelling aids, the technologies did not have a significant impact on classroom computer use. The CD-ROM in St Catherine's primary school was rarely used, because of the lack of material relevant to the primary curriculum, the palmtops in Clement infant school were only used by a small number of pupils at home,[48] and computerized spelling aids were hardly ever used in either school.[49] In fact, none of these technologies was ever observed in use. This account of computer use therefore focuses on the use of standard computer technology of the type which is widely available throughout UK primary schools.

Infant and junior classes in the field site schools only used a fraction of the software that was available to them: each class used between three and eight applications from a collection of up to fifty.[50] While there was some variation in the specific applications used in different classrooms, there was little variation in the type of applications used: infant and junior classes used word processing packages, basic practice

[48]Clement infant school received a small number of palmtop computers, which were given to a few children in each of the upper infant classes to use at home on a trial basis.

[49]It was not clear why computerized spelling aids remained unused. However, spell check facilities on word processing packages were also used rarely. One possible explanation is that teachers thought spelling aids would impede the development of spelling skills in the way that calculators are said to hamper the development of skills in basic arithmetic. Yet there is another possible explanation: although word processing enables children to produce work of a 'professional' quality (Papert, 1980), many adults feel uncomfortable about this. Indeed, when pupils at Clement infant school did use a spell checker to word process their work, parents who were shown the work handed it back to the teacher, saying that there must be a mistake and their child could not possibly have done the work. They expected their children to produce work of a 'child-like' rather than 'professional' quality. As Turkle (1984: 15) observes, "parents are torn about their children's involvement ... with computers ... parents see how the toys may be educational, but fear the quality of children's engagement with them".

[50]Computer use in nursery classrooms is discussed in a later section of this chapter.

exercises and adventure games.[51] Few classes used applications such as databases, control technology or LOGO. In fact, no instances of database use or LOGO programming were recorded and only two instances of the use of control technology. The use of these applications is discussed in detail shortly. However, first the implications of this pattern of computer use are considered.

The use of these applications does not meet either the demands of the National curriculum (DES, 1989 or the expectations of educational technologists (e.g., Papert, 1980; Chandler, 1984). National Curriculum legislation demands the use of a wide range of applications to meet five different strands of the IT Capability; data bases should be used to meet the aspect on 'Handling Information', control technology should be used to meet the aspect on 'Measurement and Control' and LOGO should be used to meet the aspect on 'Modelling' (NCC, 1990). The only aspect of the IT Capability which was developed through computer use in these classrooms was the aspect on 'Communicating Information', which was developed through word processing. However, as the next section reveals, even the use of this application rarely met National Curriculum requirements because of the way the application was used.

While educational technologists like Papert (1980) and Chandler (1984) advocate the use of open-ended applications, which develop high level cognitive skills in problem-solving and hypothesis-testing, pupils in these classrooms spent much of their time using 'closed' programmes

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[51] All the infant and junior classrooms used a word processing package called 'Phases', with the exception of Ms Prior's class in Clement infants school, which used 'Write On' and 'Write' on an IBM-compatible PC. The infant classrooms with BBC computers also used a word processing package called 'Folio'. The most commonly used basic practice exercise was 'Animated Alphabet' (a simple language game in which letters come to life). The most frequently used adventure games were 'Hector's House' and 'Granny's Garden'. In addition, all nursery and infant classrooms used an application called 'My World', which comprises a set of simple sorting and matching games.

(basic practice exercises and adventure games), which focus on low level cognitive skills such as spelling, word recognition and basic arithmetic. Moreover, there is evidence that this pattern of computer use is common in other classrooms. Surveys by the Department for Education (DES, 1991a; DES, 1992; DfE, 1993) reveal that next to word processing, basic practice exercises are the most frequently used application in most UK primary schools, and evidence from the United States (Becker, 1985) suggests that this pattern of computer use is also common outside UK schools.

Despite high levels of resources, support and training, computer use in the field site classrooms failed to meet National Curriculum requirements (DES, 1989): computers were used for word processing, basic practice exercises and adventure games, but not for programming, database or control work. This raises the question of why certain applications were used rather than others. In the following sections of this chapter, many other questions are raised about computer use in these classrooms; questions such as why applications were used in certain ways rather than others, why they were used in specific circumstances, at particular times of the day and by particular pupils. The answers to these questions are complex. Certainly, they involve factors such as the distribution of computer resources and the level of training and support for the use of these resources. Yet these questions can only be answered fully by considering the way that teaching and learning activity is organised in classrooms. Indeed, as the following sections of this chapter demonstrate, the significance of poor resources, training and support also needs to be understood in terms of the organisation of classroom activity.

The next section of this chapter focuses on the use of word processing packages in classrooms. Word processing packages were the most frequently used application in the field site classrooms. Indeed, they are the most frequently used application in most other UK primary classrooms (DfE, 1993). Word processing is an activity which has the potential to meet National Curriculum requirements (DES, 1989). However, as the next section reveals, word processing in the field site classrooms often failed to fulfil this potential, because of the way the application was used.

Word processing as copy-typing

This section begins with a description of word processing activity in Ms Jenning's infant classroom at Priory Lane primary school:

> Two pupils are sat at a computer. One of the pupils reads from an exercise book. She reads aloud from a story she wrote earlier in the week, a story which the teacher has already corrected. As she reads, her friend types. She types the story *sentence for sentence, word for word*. Every few minutes, the pupils swap roles. When they have finished typing, they print the story and join the queue of pupils at the teacher's desk. The teacher cuts the print-out to size and sticks it in the exercise book next to the hand-written original. She asks the pupils to print another copy in larger print. This copy joins the 'information technology' display.

The National Curriculum Council (NCC, 1990: C6) advises that "the computer should be used for drafting rather than presenting work which has already been hand-written". However, word processing applications were rarely used to draft work in the field site classrooms: They were used to copy-type work which had previously been hand-written in exercise books (see Appendix B for a photograph of a pupil copy-typing). Recent surveys of computer use by the Department for Education (DES, 1991; DfE, 1993) give no indication of the extent to which this use of word processors is typical of other classrooms. However, an HMI inspection of primary schools between 1987 and 1989 (DES, 1991a: 7) did report that too often the potential of word processing was lost because "hand-written originals that had been corrected by the teacher were painstakingly copy-typed with little thought for content or style".

Pupils generally copied work from their books sentence for sentence, word for word. They rarely engaged in spontaneous editing or revision, and only occasionally added colour or graphics to their work (see Appendix D for examples of this work). This was true of pupils in junior as well as infant classes. Most pupils typed with only one finger of one hand and spent an inordinate amount of time 'hunting' around the keyboard for the right keys. As a result of their poor typing skills, many pupils felt that using a word processor was slower and more difficult than writing in their exercise books and few appreciated the easy editing functions of the technology. For example, one pupil in Ms Jenning's class commented that word processing was harder than writing in his book "because I can't find the keys", while a pupil in Mr Andrew's infant class thought that it was easier to correct work in her exercise book than on the computer "because you can just rub it out. On the computer you have to go to the letter that's wrong and then delete it out".

Other studies of word processing (Carroll and Mack, 1983; Mack, Clayton and Carroll, 1983) suggest that people learning to use word processors often apply the 'typewriter metaphor' to their experience. That is, they "spontaneously try to relate what they know about type writing to text editing" (Mack, Clayton and Carroll, 1983). According to this view, it is only to be expected that children learning to use word processing applications begin by typing pieces of previously hand-written work, before moving on to use the editing facilities of the application. Yet this is not an adequate explanation for the use of word processors as type-writers in the field site classrooms.

Firstly, unlike the office staff in Carroll and Mack's studies (1983; Mack, Clayton and Carroll, 1983), most pupils had no prior experience with typewriters. Secondly, while it is true to say that slightly more drafting activity took place in junior than infant classrooms, copy-typing still dominated the experience of older pupils. Thirdly, it was teachers, rather than pupils, who generally decided whether pupils should draft or copy work: Teachers retain control over most aspects of classroom computer use, as other sections of this chapter demonstrate. Finally, analysis of teachers' accounts of computer use and of the conditions under which drafting activity took place suggested another explanation; an explanation which involved the technical, physical and social circumstances under which classroom computer use took place.

The departure point for this explanation is a set of technical circumstances; the hardware distribution of 'one computer per classroom'. Since most classrooms had only one computer, computer use took place alongside other classroom activity. Generally, one or two pupils would work at the computer while the rest of the class was working on other tasks (see Appendix B for a photograph of computer use in the context of other class activity). So, to return to Ms Jennings's classroom; while two pupils were copy-typing at the computer, the rest of the class was engaged in other activity:

> Pupils are sat around tables in groups of 4 to 6, writing in exercise books. They seem busy and the room is quiet except for a low hum of activity. A steady stream of pupils queues at the teacher's desk with spelling queries, work to be marked and pencils to be sharpened. When the queue diminishes, Ms Jennings circulates around the classroom from table to table, checking pupils' progress, setting new tasks for those who have finished work and admonishing those who have not yet finished.

Although Ms Jennings monitored class activity closely, she rarely intervened in activity at the computer. This was also the pattern in other classrooms: Computer use was almost always unsupervised. The next section of this chapter discusses classroom computer use as an unsupervised activity, and it demonstrates that word processing applications were often used to copy-type rather than draft work, because copy-typing requires far less teacher supervision.

Computing as an unsupervised activity

Almost all computer activity in the field site classrooms was unsupervised. Teachers only sat with pupils at the computer for prolonged periods if another member of staff (such as a student teacher, nursery nurse or support teacher) was present, and they rarely intervened in computer activity. Ms Nicholson, a junior teacher at St Catherine's explained "you just keep your eye on [the computer] and if you think that they need help you go over". Most teacher intervention in computer activity occurred at the request of pupils. Ms Jenning's explained:

> I very rarely go over to the computer ... but if they get stuck ... most [pupils] will be following you round the classroom going "miss, miss it won't do this" or "how do you do this?".

Teachers usually intervened in computer activity if pupils "got stuck". That is, they intervened to sort out technical problems, not to discuss the content or quality of pupils' work. Teachers also intervened in computer activity to caution pupils about their behaviour. Ms Prior at Clement infant school described the 'signals' which told her that she needed to intervene in computer activity:

> Em, kids are arguing. You know, one wants to go one way, one wants to go the other. Yeah, that's obvious. I mean wherever I am in the room it's in view and I tend to know what's going on. And well normally if there's something wrong with it you know on the screen, they normally come across and say "look this has happened and I pressed that and I don't know what to do".

There is evidence to suggest that computer use in most primary classrooms is unsupervised: An HMI survey of computer use in over 200 primary schools (DES, 1991a: 12) found that pupils working at the computer received "little immediate support from the teacher". However, giving support to pupils at the computer places teachers in a dilemma. As Mr Holland at Clement infant school observed, in addition to the pupils working at the computer "you've got 24 other children who want something or need your help".

In order to fulfil their teaching role, teachers need to maximise the involvement of all pupils in effective learning activity (Westbury, 1973). Working with just one or two pupils at the computer leaves the rest of the class in a less effective educational setting: By minimising contact with computer users, teachers are able to maximise their involvement with the rest of the class. Indeed, teachers generally gave less supervision to pupils engaged in computer activity than they did to pupils engaged in other types of activity. Ms Kerr at St Catherine's primary school observed:

> If I'm floating around the classroom, I'll make sure that I keep an eye on [computer activity]. But if I'm honest it's easier to let it ... it's one of those activities that you might not push as much as you should because you know they're getting on.

Computing was perceived as an activity which required less intensive teacher input than other types of learning activity. Pupils could 'get on' with computer activity as they might 'get on' with reading a book. As a later section of this chapter demonstrates, teachers often used the computer as a substitute teacher, sending pupils to use it if they finished their work before the rest of the class. Indeed, one teacher at Range even described the computer as "another teacher in the classroom".

One possible explanation for the use of computers as 'substitute teachers' is the idea that people have a natural tendency to ascribe human qualities to machines which demonstrate evidence of human abilities. Suchman (1987: 17) argues, for example:

> Computational tools seem to offer unique capabilities for the provision of instruction to their users. The idea that instructions could be presented far more effectively using the power of computation is not far from the idea that computer-based artefacts could actually instruct: that is, could interact with people in a way that approximates the behaviour of an intelligent human expert or coach.

However, the perception of computers as substitute teachers in the field site classrooms had as much to do with the social organisation of teaching and learning as the capabilities of the machine. Teachers perceived computing as a self-instructional activity because of the problems that they faced in the specific circumstances in which they taught. If teachers intervened in activity at the computer, they not only risked leaving the rest of the class in a less effective educational setting: They also risked classroom control:

> When [pupils] come to a problem it's got to be solved right there and then for them. So you've got to intervene. So you're like concentrating on the computer. You've got your back to the rest of the class and obviously that can create a two-way situation where, you know, you can lose a bit of control.
>
> *Mr Andrews, Range primary school*

> When you've got 30 odd kids as soon as you've got your back to them they're running riot and ... you know, it's like one hand on the computer right let's try this let's try that, looking around all the time and I can't do it.
>
> *Ms Jennings, Priory Lane primary school*

> When you've got like 35 kids swarming around the classroom you've got 2 on the computer who say "what do you do now?" and you're like "Oh my God I can't do that as well".
>
> *Ms Kerr, St Catherine's primary school*

Classroom control is crucial to the enterprise of teaching (Nias, 1989; Woods, 1977; Pollard, 1980; Olson, 1992). Indeed, teachers regard 'being in control' as *the* one necessary condition for 'being a teacher'

(Nias, 1989). Teachers have to establish a sense of authority and achieve "compatible behaviour" from pupils in order to influence learning activity and fulfil their teaching function (Pollard, 1980). However, losing control does not only have practical repercussions for teachers: It also implies a lack of professional competence. Woods (ibid.: 40) argues:

> Teachers are accountable in many diverse ways. At the level of the school there is the staff/peers evaluation of the teacher - 'a good disciplinarian', 'hopelessly disorganised' - in which most teachers will want to secure a positive evaluation. The most important index here, and very much endorsed by the headteacher's organisational concerns, tends to be how well 'ordered' or 'under control' the teacher's class is.[52]

The concept of classroom control is central to this theory of computer use. In order to reduce the risk to classroom control, teachers limit their intervention in computer activity. In order to limit their intervention in computer activity, they carefully control different aspects of computer use. One of the ways that teachers reduce the risk to classroom control is by locating computers centrally within the classroom, as mentioned in an earlier section of this chapter: Teachers locate computers in areas which can be monitored from elsewhere in the classroom and, more importantly, from which they can monitor activity in other parts of the classroom (see Appendix C for a plan illustrating a central computer location). Teachers also reduce the risk to classroom control by using certain applications rather than others and by using those applications in particular ways.

Teachers in the field site classrooms associated different types of computer activity with different supervision needs. Many of the activities required by National Curriculum legislation (DES, 1989) were perceived to require intensive supervision:

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[52]The issue of how teachers produce and recognise the appearance of 'order' or 'control' is considered in a later section of this chapter.

> It's a shame, but I can't do anything intensive like [control work] when I'm on my own.
>
> *Ms Kerr, St Catherine's primary school*

> To do [control work and database work], you'd need the time with small groups of children to show them what to do. And you'd need a class that allows you to break off with a small group.
>
> *Mr Andrews, Range primary school*

Control work, database work and LOGO programming were all perceived by teachers to be activities which required more intensive supervision than they could provide under 'normal' classroom conditions; that is, when they had sole responsibility for a full class of between 25 and 35 pupils. Indeed, the only times that control work did take place in the field site classrooms, it occurred with small numbers of pupils, who were intensively supervised:

> *20 May, 1993*
>
> Mr Andrews tried some control work with his class this morning. Two extra computers were bought into the class and pupils built model cars using Lego. They then controlled the cars from control interfaces. Half the class had gone swimming, so there were only 12 pupils present, who were split into groups of 4. Each group was supervised by an adult: I supervised one group and the other groups were supervised by support workers, usually assigned to help disabled children. Mr Andrews floated around the class, monitoring activity.

> *8 June, 1993*
>
> Ms Kerr's class used floor turtles to do control work today. Mike, the technology ancillary, organised the activity in the technology resource room. He bought pupils out of Ms Kerr's classroom 12 at a time. These pupils were split into groups of 3, and Mike and I supervised 2 groups of pupils each. Even with just 12 pupils in the classroom, the sessions were hectic. The initial idea of racing turtles around a track proved to be too complex and was simplified after the first session. Ms Kerr said that she would try to look in on the activity, but she was unable to leave her class and did not actually get a chance to see her pupils using the turtles.

While control activity, database work and LOGO programming were seen as activities which demanded intensive supervision, basic practice exercises and adventure games were perceived to require less teacher input:

> I like the stuff where they have to make decisions like adventure games. There's adventure games for the BBC where they do maths and co-ordinates and I can just leave them to it. They can just use them independently.
>
> *Mrs Wilson, Priory Lane primary school*

> Because you can't spend all the time [at the computer] you need something that is just a bit mindless really don't you? So that they can just go and have a play on it.
>
> *Mrs Ellis, Clement nursery*

> [I look for applications] that actually tell you what the next step is. Like ...when you have to put the password in and then it says "now press space bar to continue"... and the children can read that and they know what to do. And those where just the next screen comes up and you put whatever information you want in and then you think right now what happens. So the actual ones that tell you what to do are better ... the kind of thing that explains to you what you do next. Because often you just think "oh, what do I do now?" and that's when you have to start experimenting and wasting your time.
>
> *Ms Jennings, Priory Lane primary school*

While educational technologists (Papert, 1980; Chandler, 1984) and legislators (DES, 1989) advocate the use of open-ended 'tools', which encourage exploratative learning, teachers in the field site classrooms favoured 'closed' packages, which require less supervision. However, there was one open-ended 'tool', which was popular in classrooms; word processing. Yet word processing, too, was interpreted as a 'closed' activity; copy-typing.

Like basic practice exercises and adventure games, copy-typing was an unsupervised activity in classrooms. However, the use of word processors for drafting was perceived as an activity, which would require greater supervision:

> It would take forever [to draft]. It would take absolutely forever. And I think only the older children could do it at all. I think I tried it once and it just seemed to be a total disaster so I didn't bother.
>
> *Mr Holland, Clement infant school*

> [If pupils were to draft] they would just sit there and do nothing or they would be at my desk bothering me all the time about how to spell words and I'd just be telling them to go back and think about it and do it for themselves.
>
> *Ms Jennings, Priory Lane primary school*

The problems associated with using word processors to draft rather than copy-type previously hand-written work became evident during observation in Ms Prior's classroom at Clement infant school:

1.35 pm	Mark begins to draft a story on the computer. He is continuing a piece of work begun earlier in the day. Ms Prior is sat at a table near the classroom door hearing pupils read.
1.40 pm	Mark goes to Ms Prior with a spelling query.
1.47 pm	Mark goes to ask Ms Prior about another spelling.
1.52 pm	Ms Prior looks over to check the computer screen.
1.53 pm	Mark goes to Ms Prior with another spelling query.
1.57 pm	Mark goes to Ms Prior with another spelling query.
1.58 pm	Mark goes to Ms Prior with another spelling query.
2.00 pm	Mark calls over to Ms Prior "Ah miss, I've done it wrong!". Ms Prior goes over to the computer to see what the problem is. She explains to Mark that too many letters have appeared because he left his finger on the key too long. Ms Prior now moves to sit next to Mark. She marks exercise books and answers spelling queries almost every minute.
2.08 pm	Ms Prior moves to the table nearest to the computer and continues marking exercise books.
2.11 pm	Ms Prior looks over to the computer screen, notices a problem and goes to the computer to delete some text.
2.17 pm	Mark asks Ms Prior about another spelling.
2.18 pm	Mark asks Ms Prior how to scroll up the page.
2.20 pm	Mark tells Ms Prior that he has finished. Ms Prior goes to the computer to read his story. She then shows Mark how to print his work.

During forty minutes of drafting, Ms Prior had to intervene in the activity eighteen times, mostly to answer spelling queries. For this teacher, in these circumstances, a high level of supervision was possible. It was doubtless facilitated because the rest of the class was engaged in a similarly 'self-contained' activity; 'silent reading'.

However, for other teachers in different circumstances, this level of supervision was not possible.

Teachers perceived different types of computer activity to be possible in different circumstances. Their perceptions of what was possible related both to the amount of intervention that they perceived to be necessary in different types of activity, and to the 'threat' that such intervention might pose to classroom control. Both the intervention necessary in activity and the 'threat' of this intervention were seen as variable.

The perceived 'threat' to classroom control was related to the length of time that teachers had taught a class, the behaviour of pupils (particularly of pupils identified as disruptive) and how 'well' teachers felt at a particular time:

> I've just got a new class. There are 29 of them and 6 are problems. If I went out to the computer to show them what to do, I'd be surrounded by chaos.
>
> *Mrs Wilson, Priory Lane primary school*
>
> I've had the new computer for a week already, but I was ill so I didn't feel up to doing much with computers.
>
> *Ms Jennings, Priory Lane primary school*

New classes, 'problem' pupils, stress and ill health all threaten teachers' ability to cope in the classroom (Pollard, 1980). Teachers who had recently taken over new classes perceived the threat to classroom control to be particularly great. For two teachers at Range, the threat was so great that they did not use computers at all during their first terms with new classes. Ms Anderson "could not face wrestling with the computer" during her first term with a particularly difficult class, while a colleague also left the computer switched off because of the difficulty she had "just getting this class to settle down to work".

Woods (ibid.) argues that the 'getting to know each other period' with new classes is an especially difficult time for teachers: They must establish their authority and set up routines and procedures about 'how things are done'. Under these circumstances, computer activity can be particularly risky, not just because of the difficulty of intervening in the activity, but also because of the perception that computer activity is a 'treat' rather than 'real work', and because of teachers' relative lack of expertise with the technology. These factors are discussed in detail later.

Teachers also perceived the amount of intervention necessary in computer activity to be variable. This perception was related not only to the type of application used (word processing/basic practice exercises/adventure games versus databases/control applications/ LOGO) and the way it was used (drafting versus copy-typing), but also to the age and ability of pupils. Younger or less able pupils were generally perceived to require more supervision in computer activity than older or more able pupils. Consequently, teachers perceived different types of activity to be possible with pupils of different age and ability:

> The thing with nursery pupils is, someone needs to be with them all the time to watch what they're doing and help them with it. There's only two of us in the nursery and if one of us was at the computer all the time, it would just be too much.
>
> *Mrs Carter, St Catherine's primary school*

> The older the children the more you can do with them [on the computer]. I mean you can do things with them when they're young. But as for writing, for word processing, it's definitely age and it's more one to one being with a child.
>
> *Mr Holland, Clement infant school*

> I'm looking for something for the less able kids because apart from a matching game or a sorting game or something ... there's not really a lot that they can do.
>
> *Ms Prior, Clement infant school*

> I [used games] more when I had a younger class ... because a lot of the games are pictures ... so they're easier to use and they introduce language.

> The pictures make the language obvious so they can use those. I haven't used [games] as much now with [juniors].
>
> *Ms Nicholson, St Catherine's primary school*

Although word processing was the most popular application in almost all classrooms, older, more able pupils generally spent more time word processing than younger, less able pupils. In contrast, younger, less able pupils spent more time using basic practice exercises and adventure games. When the Department for Education (DfE, 1993) surveyed computer use, they found a similar pattern: pupils in junior classes spent more time word processing than pupils in infant classes, but less time using practice exercises and puzzles. In the field site classrooms, this pattern was related in part to the perception that younger pupils' had poorer literacy skills and required more supervision during word processing activity than older pupils. However, as a later section of this chapter demonstrates, it was also related to the perception that older pupils should spend more time 'working' than younger pupils.

Teachers used many different strategies to limit their intervention in computer activity. Some have already been mentioned; the use of particular applications rather than others, the use of applications in particular ways and the matching of activities to pupils' age and ability. However, some teachers also made physical changes to the technology. For example, several infant teachers put lower case letters on upper case keyboards because pupils had difficulty recognising capital letters:

> [Pupils] find [word processing] easier now because they've put lower case letters onto the keyboard. Because they couldn't transfer ... the capitals and just didn't know what they were writing ... so we've made all of [the keys] lower case. We've put stickers on them.
>
> *Ms Kerr, St Catherine's primary school*

Other teachers disabled peripheral devices which were problematic. For example, teachers at Clement nursery switched the printer off unless one of them was available to monitor computer activity, and they sometimes tucked the mouse away out of pupils' reach (when the touchscreen was in use, for example). However, one of the most common strategies used by teachers to reduce the need for intervention was that of 'pairing pupils':

> I put a child that's really good with a child that's not. Like an older child with a younger child. And I mean quite a lot of them can get that to work. You know ... usually older children can reload and sort themselves out a bit and sort the various stages of the game out for themselves.
>
> *Mr Holland, Clement infant school*

Teachers often paired younger or less able pupils with older or more able pupils during computer activity in the hope that the more able would 'teach' the less able. Other studies of primary computer use (e.g., Jackson, Fletcher and Messer, 1988) also refer to this phenomenon, often called 'peer teaching'.

This section has demonstrated that computing was an unsupervised activity in primary classrooms, and it has suggested why this was the case: Since classrooms have only one computer, computer activity takes place alongside other classroom activity. By supervising activity at the computer, teachers risk leaving the rest of the class in a less effective educational setting and, perhaps more importantly, they risk classroom control. Teachers therefore limit their intervention in computer activity; by using certain applications rather than others, by using them in particular ways, by making physical changes to the technology and by pairing pupils.

The use of 'computer experts' can also be an effective strategy in reducing teacher intervention in computer use. 'Computer experts' are particularly experienced pupils, who act as 'trouble shooters' and whose expertise is widely recognised by both teachers and pupils. Olson (1992) suggests that computer experts are common in primary classrooms. However, they were rare in the field site classrooms. In fact, they only operated in two classes, where specific conditions existed. As the next section demonstrates, pupil expertise can be threatening to some teachers.

Teachers are the experts

The benefits of teachers "learning alongside pupils" are widely recognised (Underwood and Underwood, 1990; Olson, 1992). In this model of learning, teachers are not 'vessels of expertise'. Instead, teachers and pupils acquire skills together. This model of learning has particular relevance for classroom computing. Computing is the area of the primary curriculum, in which teachers receive least instruction prior to becoming teachers: Most teachers still do not have regular access to computers during initial teacher training (Rhodes and Cox, 1990). Pupils, on the other hand, often do have experience of the technology outside the classroom: Almost all pupils are regular users of computer games. Indeed, some teachers not only felt that pupils had more computer experience than they did: They also believed that pupils were simply 'better' with computers. As Ms Jackson put it, "pupils aren't like us. They pick computers up really easily".

In most classes, there were at least one or two pupils, who were particularly competent computer users. Yet only two teachers allowed these pupils the status of computer experts, calling on them to fix problems and give assistance to other pupils; Ms Anderson and Ms Prior:

> If I'm working with a kid and somebody's got confused or has lost whatever they're doing I'll say Tony or Chris can you go and sort the

> computer out, which they do. Probably if I was doing something or I wanted to run Microman or something which I've never played ... then I would call them over and say, you know, what do you do now.
>
> *Ms Prior, Clement infant school*

> If they have problems [with the computer] I just call on Jason. He sorts it out.
>
> *Ms Anderson, Range primary school*

By using computer experts in their classrooms, Ms Anderson and Ms Prior were able to reduce their intervention in computer activity and spend more time with the rest of the class. Furthermore, pupils were able to use computers in ways which would not otherwise have been possible. For example, Ms Prior described how computer experts in her class facilitated the use of a database:

> With Tony and Chris, once you've shown them they can go off and do it by themselves ... so they can switch on the computer, they can choose the database icon and choose whatever. And they can do all that by themselves. Which I must admit if they couldn't and they therefore couldn't show other kids what to do, I would find it very hard. Because it would be planning you know. You'd have to spend say five minutes at the beginning with the kids who were working on it and ... they would have to wait until you'd sorted everybody else out before you could go over there.

In view of the benefits associated with the use of computer experts, it was surprising that they did not operate in more classrooms. However, a technology support teacher observed:

> You can only use [computer experts] in some classrooms. It doesn't work in all of them. I've been in classrooms where it wouldn't have worked because the teacher just wouldn't have been comfortable with it. They want to be the person in control.

Many teachers did not want to learn alongside pupils: They wanted to be 'one step ahead' of them. Pupils who were 'one step ahead' of teachers threatened their ability to diagnose and remedy learning difficulties and, hence, their ability to direct learning activity. As Ms Kerr pointed out, "if I don't know what [pupils] are supposed to do on [the computer] I can't expect the kids to do anything useful because I'm not even pushing them".

However, computer experts did not only threaten teachers' ability to influence learning activity. They also threatened classroom control. Teachers' sense of authority is vested to a great extent in their status as 'experts' (Olson, 1992). Pupil experts challenge the balance of power. The only classes where computer experts operated were classes where teachers drew more on personality than expertise for their sense of authority: Ms Anderson and Ms Prior were young, enthusiastic teachers, who had an especially close relationship with pupils and were known among colleagues for the 'warm atmosphere' in their classrooms.

While Ms Anderson and Ms Prior had the confidence to try 'new' applications in the classroom, most other teachers used only a few programs that they were familiar with:

> I feel more confident if I know what [pupils] are doing. Because if they do something wrong or they get stuck then, you know, you feel a bit of a wally.
>
> *Ms Jennings, Priory Lane primary school*

> I tend to stick with programs that I'm confident with so that I know what to do if ... they get confused half way through ... I just get too stressed when things start going wrong.
>
> *Ms Kerr, St Catherine's primary school*

When teachers faced problems that they could not deal with, it was very stressful: They were unable to leave their classrooms to ask other teachers for help, and they had no immediate access to technical support.[53] Moreover, they could spare no more than a minute or two of lesson time to deal with the problem because of the risk to other learning activity and classroom control:

> This morning I didn't know how to save. I tried and [the computer] lost the work. So then I had to wait and ask [the technology ancillary] how to do it at playtime ... at dinner time I came back and I did one on my own

53Technicians from the ICT project visited schools on a weekly basis.

and saved it just to make sure that I knew how to do it. But I couldn't do that with a class full of children because it takes too long.

Ms Jennings, Priory Lane primary school

Hence, if teachers were unable to solve computer problems "at the push of a button", they usually switched the machine off until they or someone else could deal with the problem during a break or lunch time. As Mrs Wilson put it, "if you can't do it straight away, if at first you don't succeed, give up is my motto on the computer".

To summarize, most teachers in the field site schools were uncomfortable learning computer skills alongside pupils and were reluctant to place themselves in situations where they might be exposed as inexperienced or incompetent: Teachers wanted to stay at least 'one step ahead' of pupils, so that they could influence learning activity and maintain classroom control. Hence, they were reluctant to experiment with 'new' applications in the classroom and tended instead to use just a few familiar packages.

Previous sections of this chapter have emphasized the significance of classroom control in computer use, but have said little about what classroom control is. The following section examines how teachers produce and recognise the appearance of classroom control; a phenomenon which is grounded not only in the social organisation of primary schools, but also in their physical organisation.

Control in 'closed' classrooms

When teachers intervene in computer activity, they risk 'classroom control': The single most important indicator of this risk is classroom noise:

> [When you intervene in computer activity] you've got your back to the rest of the class and obviously that can create a two-way situation where you can lose a bit of control. Not for long. They'll most probably *just get noisy* [emphasis added] so that means you've got to stamp down again at a period when maybe things have been going quite nicely.
>
> *Mr Andrews, Range primary school*

Teachers in the field site classrooms were particularly sensitive to noise. Their classrooms were quiet places, where noise was tolerated rarely.[54] Teachers constantly reminded pupils of the need to "work quietly" and they intervened more frequently in 'noisy' behaviour than other types of problem behaviour, insisting that pupils "be quiet" and "stop talking". New or sudden noise was a cue that something significant was happening, which required urgent attention.

Some teachers perceived computer activity to be 'noisy' and felt that it distracted pupils working nearby. As a result, they did not use computers during 'quiet' lessons and sometimes placed machines in an alcove away from the main classroom:

> If the computer is switched on it's very distracting because all the children sat on the table nearest to it want to get on there ... but if it's quite a noisy afternoon, it's really good, you know, just to get some more stuff done on it, but in ... quite a structured lesson, the computer can be noisy and can cause problems.
>
> *Mr Holland, Clement infant school*

> [The computer isn't used] during quiet reading, which we normally do on a Monday morning, em sort of discussion work, listening, speaking.
>
> *Ms Prior, Clement infant school*

> I don't think I'd want both computers going in the classroom at the same time ... because of the noise. It's dreadful.
>
> *Mrs Wilson, Priory Lane primary school*

Denscombe (1980: 62) argues that teachers are sensitive to noise because it poses a problem for the practical activity of teaching; "noise interferes with instruction by teachers and concentration by pupils and

[54]Different levels of noise were tolerated in different classrooms and at different times of the day. This is discussed in detail later.

therefore hinders the learning process". However, noise is not only a practical problem; "noise emanating from classrooms carries with it connotations of a lack of control in the classroom and a certain lack of competence on the part of the teacher" (ibid.: 62). Noisy pupils imply a lack of classroom control and a lack of teacher competence. Noise has this significance because it is one of the few 'publicly available' sources of information about what goes on behind closed classroom doors.

The field site schools were organised according to the 'closed' classroom tradition, originally introduced to deal with mass education in the nineteenth century (see Appendix E for a diagram of this arrangement). The ‘closed’ classroom organisation typically entails rectangular, self-contained classrooms, separated from others by walls and corridors, each containing one teacher with a number of pupils (ibid.). Teachers spend their working lives in isolation in these classrooms, with little opportunity to observe their colleagues. Noise is one of the few sources of information which transcends the isolation of the setting. In the absence of direct observation, it provides 'evidence' of teacher control in the classroom. Hence, classroom control is not so much a literal state as a socially organised phenomenon; "it is the product of inference, appearance and interpretation, by both the classroom teacher and colleagues outside the bounds of the closed classroom" (ibid.: 73). By limiting their intervention in computer activity, teachers avoid creating the 'appearance' of a lack of control, conveyed through classroom noise.

The next section of this chapter considers another source of information within the closed classroom organisation; the tangible paper product. In the field site classrooms, teaching and learning activity took place behind closed doors, invisible to all but the teacher and pupils involved: paper products provided 'evidence' of this activity.

The significance of paper products

Although teachers work alone in closed classrooms, they are accountable to people outside classrooms, who require evidence that they have 'taught' and pupils have 'learned'. Teachers need to show headteachers, other teachers, parents and inspectors that pupils have 'made progress'. However, not all computer activity generates evidence of progress:

> We have a file for computer work that passes up just to keep a record of things ... And last year I sent up loads of work in it because I did a lot of [word processing] work and it was all printing out and a lot of [art] work. But this year ... I've done loads of mouse control ... and nothing comes *out* [original emphasis] of it, you know. Well, you know, physically, a physical product ... *I* [original emphasis] don't mind because I can justify in my planning ... what they've done. But you do get worried about well, where's the evidence of learning? And if you were to have an inspection ... I've got no evidence to prove it apart from that I've written in my planning that they did it. It's dodgy ground. It's like anything isn't it? Practical maths work is so important but then people say well, where's all the work? And you say well it's in my head, you know, it's in the skills. But parents still come in and say "can I see the maths book?"
>
> *Ms Kerr, St Catherine's primary school*

> [Print-outs] are important for [pupils] because they like to see ... their work ... and for me it's important, you know, for work to go in their files, work to go on the board and as a record. Because ... you think I must remember they can do that and they've done this and if you've got some hard evidence there, you know, especially now with all the recording and assessment that you have to do for the National Curriculum, if you've got a piece of work there, you can say tick, right, there it is.
>
> *Ms Jennings, Priory Lane primary school*

In formal education, teaching and learning have long been measured by filling notebooks with facts, which pupils memorise in order to pass examinations. Notebooks and examination results constitute evidence of learning (Olson, 1992). However, for computer activities such as LOGO and control technology, the 'learning is in the doing'. There is no tangible evidence of the 'critical thinking skills' that these activities develop.

While many computer activities do not generate hard evidence of learning, word processing does. It results in a 'print out'. Teachers often printed several copies of word processed work, which were stuck in exercise books (see Appendix D), placed in 'good work' folders and added to 'pupil profiles'. Teachers also exhibited word processed work in prominent classroom displays, often adding colour and graphics. Work for display was particularly important: Classroom walls were covered with examples of 'good' work (see Appendix B). In closed classrooms, with few publicly available sources of information, these displays conveyed powerful messages about teaching and learning activity.

Given the significance of tangible products within the closed classroom organisation, it seems likely that the popularity of word processing in the field site classrooms was due in part to the paper product generated by the activity. Yet, if there is a genuine link between the popularity of a computer activity and its potential to generate hard evidence of learning, this raises an important question: Why are basic practice exercises and adventure games so popular in classrooms, when these activities do not result in a product?

The next section answers this question. It argues that the value attached to the products of computer activity depends on the value attached to the activity itself, and not all computer activities are perceived to be of equal value: Some classroom computer activities are seen as 'work', some are seen as 'play' and others involve 'messing around'.

Computing as work, play and 'messing around'

The value of tangible products depended on the type of computer activity that they represented. If pupils were engaged in 'work' activity, products were regarded as important. However, if pupils were 'messing around' on the computer, it was less important that the activity generated a product:

> It's alright if [pupils] are just messing around and using [the computer] to learn how to use the keyboard and learn how to use something ... but if we're doing some work, like ... writing in their diary, they want to see it printed or have it up on the wall or stuck in their book for mums to see.
>
> *Ms Jennings, Priory Lane primary school*

The terms 'work' and 'messing around' were used frequently by teachers to describe computer activity, as was the term 'play'. However, these terms were not only used by teachers. Pupils also recognised that some types of computer activity constituted 'work', while others did not:

> Interviewer: What do you use computers for in school?
> Simon: Playing, writing and drawing
> Interviewer: Is writing and drawing different from playing?
> Simon: Yep.
> Interviewer: How's that different?
> Simon: Because you don't get to play when you're writing and drawing.
> Interviewer: That's not playing?
> Simon: No.
> Interviewer: What's that?
> Simon: That's doing something. That's working.
>
> *Excerpt from interview with Simon, aged 7, Ms Prior's class*

Teachers and pupils shared an understanding that some types of classroom computer activity constituted work and some constituted play, while others were part work and part play: They were 'messing around'. These understandings of computer activity were complex. Indeed, the distinctions between the different types of activity were not always clear. Some activities seemed to straddle the categories, while other activities had different meanings in different circumstances. There was one activity, however, whose meaning was always clear; word processing:

> [Pupils] can write [on the computer] but normally they don't want to do that because they see that as work.
>
> *Ms Prior, Clement infant school*

> Interviewer: When you go on the computer are some things a bit more like working and some things a bit more like playing?
>
> Karen: When you write on the computer, that's like working. You are working.
>
> Interviewer: So why is that like working?
>
> Karen: Because when you're working you write and when you're on the computer you write.
>
> Interviewer: And what do you do when you play games?
>
> Karen: That's not work.
>
> Interviewer: Why not?
>
> Karen: Because all you're doing is playing, but you are learning to play games.
>
> *Excerpt from interview with Karen, aged 6, Mr Holland's class*

Word processing was seen as part of the work of the classroom; an extension of general writing activities. Language and literacy development are central to the primary curriculum, and pupils spent a large part of the school day writing stories, poems, letters and diaries. One or two pupils would write at the computer, while the rest of the class wrote in their exercise books. Writing at the computer enabled pupils with poor hand-writing to produce 'neater' work, while older pupils developed 're-drafting' skills:

> Last week [Sam] wrote about the trip we'd been on to Tatton Park and it was beautiful what he'd written but it looked horrible because it was so untidy and there were no finger spaces in it. And we wanted it to put on display and to read in assembly. So then he put the whole thing on the keyboard and it took ages to do it, but he sat and sat and did it because it was so nice, this piece of work.
>
> *Ms Jennings, Priory Lane primary school*

> [Word processing] fits in quite well with re-drafting work really. That's where it fits in for the [juniors] ... because they write something and then they can correct it and do it on the computer.
>
> *Ms Nicholson, St Catherine's primary school*

In primary schools, learning is work. Or rather, some learning is work. As Karen recognised, learning to play games is not work: Learning to read, write, add and subtract is work. The paper product of word processing is evidence of one of the most important work activities in the primary curriculum; learning to write. Yet, in a sense, the product is more than just evidence of work. The product *is* the work. Learning activity takes place behind closed doors. It is invisible. It is the product of the activity which is recognised by other teachers and parents as work. As the technology support teacher at Priory Lane primary school observed, "[Ms Jennings] used computers quite a lot. She did a lot of printing out". 'Print-outs' are not just evidence of computer work. They are computer work.

'Print-outs' from word processing are not only evidence of writing activity. They are also evidence of a computer activity, whose value is inscribed in National Curriculum legislation (DES, 1989). The legislation is explicit that the value of word processing lies in its re-drafting and easy editing facilities. These aspects of the technology were rarely exploited in the field site classrooms, because computers were used to copy-type rather than draft work. Yet, the product of copy-typing is open to interpretation as the product of drafting activity. The product disguises the process: In a sense, the educational value of copy-typing does not lie in the activity itself, but in the interpretive flexibility of the paper product that it generates.

While word processing generated a tangible product, the use of basic practice exercises and adventure games did not. However, unlike word processing, basic practice exercises and adventure games did not constitute 'work':

> On the BBC we had a thing called 'Animated Alphabet' and [pupils] loved that and, you know, they didn't see that as work and they wanted to play it.
>
> *Ms Prior, Clement infant school*

> The 'My World' [programs] are nice for [pupils] to play around with but ... they don't really stretch them ... they're good for using the keyboard and getting used to the mouse and that sort of thing.
>
> *Ms Jennings, Priory Lane primary school*

> With the BBC, we used to just do [word processing] but since we've had the A3000 we've used packages like 'My World' and the talking books and just had a bit of fun with it.
>
> *Ms Kerr, St Catherine's primary school.*

While word processing was perceived as a 'learning' activity, the use of adventure games and basic practice exercises was not. This is not to say that learning did not take place during these activities. Rather, their value as learning activities was secondary to their value as 'fillers' and 'rewards'; that is, as activities which kept pupils 'busy' or rewarded them for good behaviour. The educational value of the activities was not expressed in terms of the learning of skills which are central to the primary curriculum, but in terms of the learning of basic computer skills.

'Filler' activity, or 'messing around' on the computer, was also referred to by teachers as 'not doing anything specific'. These activities were not directed learning activities, associated with specific learning objectives. Their function was to 'fill time' for pupils who had finished their work early, so that the teacher could attend to the rest of the class. Hence, filler activities such as basic practice exercises and adventure games only took place once pupils had finished other work; that is, their stories or sums.

While pupils were only allowed to use basic practice exercises and adventure games once they had finished other work, they usually 'took turns' at 'learning' activities such as word processing according to a rota:

> Say we were going to do an activity, a writing activity, well then we'd probably get one to go on the computer and the others would be doing something. And then as soon as that person had finished the next person would go and do their's. You know, they'd have something planned to do that they would take turns on.
>
> *Ms Prior, Clement infant school*

> With [word processing] we take it in turns. I just go through my class list and take the next two.
>
> *Mrs Wilson, Priory Lane primary school*

Since teachers attached specific learning objectives to word processing, they aimed to give as many pupils as possible a turn at the activity. The computer was switched on at the beginning of the lesson and while the rest of the class was working on stories or sums, pupils were sent to the computer, one or two at a time. Hence, word processing often continued throughout a lesson, while basic practice exercises and adventure games were only used during the last ten or twenty minutes, once pupils had finished other work.

Although pupils usually 'took turns' at word processing according to a rota, they were not always allowed to take their turn. If pupils had behaved badly, their access to the computer was withdrawn:

> The theory is that I have a tick list which doesn't work very well because ... it seems to be the ones who've finished their work and work hard and, you know, you kind of use it as a bribe. You know, "you're not going on the computer, you'll miss your turn on the computer if you don't ..." which is dreadful really.

The computer functioned as part of the punishment-reward system in all but one of the field site classrooms (this classroom is discussed shortly). Pupils were rewarded with access to the computer if they worked hard and behaved well, and they were denied access if they behaved badly. Teachers used the computer to obtain appropriate learning behaviour. On my first visit to Mrs Wilson's class, the following exchange took place:

> Mrs Wilson: Now you've got a nice surprise this afternoon children. Miss Croft is with us and she absolutely loves computers. They're her favourite thing. So she's going to sit here and play with them, but I know you don't like computers so we're just going to do something else. What do you think about that?
>
> The class: Ah!
>
> Mrs Wilson: So would some of you like to go on the computer then, the new one? Put your hand up if you'd like a go.
>
> [Most pupils put their hands up]
>
> Mrs Wilson: Well I can see one boy I already had in mind, but he won't be going on because he's been so naughty today. Let's see ...
>
> [Mrs Wilson picks two other pupils]

Mrs Wilson had a particularly 'difficult' class, with a high number of 'problem' pupils. As she circulated around the class, checking pupils' work, she frequently addressed them with comments like "the next two I send [to the computer] will have done all their work sensibly!", "do you want to go on the computer? Well you'd better do some work then!", and "you two won't be going on the computer. You've blown it!".

There were many ways in which the computer was used to reward and motivate pupils. Since they were only allowed to use basic practice exercises and adventure games once they had finished their 'work', 'filler' activities also functioned as a reward:

> The computer was one of those activities that filled. You know, someone had finished, "oh, go on the computer" ... it's a reward. That's what I was doing really, "oh well, you've worked hard, you can go on the computer".
>
> *Ms Kerr, St Catherine's primary school*

Word processing, too, was a reward. Pupils were sent to the computer to type up 'good' work, which was put on display (see Appendix B) and in their 'good' work folders.

The consequence of this punishment-reward system was that pupils who were bright, finished their work early and behaved well spent more time using computers than pupils who were less able or had behavioural problems:

> When [pupils] finished a task I'd say "would you like to go on the computer?" ... It was the more able kids who were always getting on it because they were finishing their work quickly. You know, it was the same kids who were bringing out computer work ... the same kids were getting the reward.
>
> *Ms Kerr, St Catherine's primary school*

> Because [Tony and Chris] are ... the most able in the class, often they've finished their work before the others so they get to go on the computer while everyone else is finishing off. So they've had more time on it.
>
> *Ms Prior, Clement infant school*

Access to computers was inequitable in all the field site classrooms. Other studies of classroom computer use (e.g., Ellis, 1986; Culley, 1988; Carmichael et al., 1985) support this finding. However, these studies report that inequitable access is the result of gender bias: teachers give boys more time and attention on computers than girls. The findings of this study do not support the view that unequal access is due entirely to gender bias. In some classrooms, the pupils who had most access to computers were boys, in others they were girls.

Teachers sent some pupils to the computer more often than others in order to keep them 'busy' and maintain classroom control. As a pupil in Ms Prior's class put it, "Tony and Chris always get to go on the computer, because they finish first and Miss learns them first. She wants to get them out of the way otherwise they're naughty".

Computers are not the only 'reward' in classrooms. Teachers offer pupils a whole range of commodities as rewards for good behaviour:

> One [bribe] is the choose time. When you finish your work, you can choose on a Friday afternoon. And if you haven't finished all your work you have to work on Friday afternoon. And then there's the negative things like you miss your playtime and you miss swimming. Most of it is you miss something. Er what else do we do as bribes? We've got this raffle for a bike at the moment and if you don't do your work your ticket gets taken out and if you do get on really well then you can have an extra chance and another ticket.
>
> *Ms Jennings, Priory Lane primary school*

'Choose time',[55] swimming trips and breaktimes all represent an escape from the 'real work' of the classroom, as does computer activity. Even word processing does not represent 'work' in the way that writing in an exercise book does:

> [Pupils] really enjoy using [the computer] whatever it is they're doing. Even if it's writing or something. It just seems to fascinate them somehow.
>
> *Ms Jennings, Priory Lane primary school*

> Kids love the computer. They absolutely love it. Chris had a sulk one day because he couldn't go on the computer.
>
> *Ms Prior, Clement infant school*

Pupils liked going on the computer, and this was crucial to the status of the activity within the punishment-reward system. Teachers recognised that computers exerted a powerful motivational force.[56] Given pupils'

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[55] 'Choose time' is discussed in more detail shortly.

[56] See Turkle (1984) for a discussion of the 'holding power' of computers and children's responses to the machine.

enjoyment of computer activity and the significance of classroom control for the enterprise of teaching, it is not difficult to understand why computers were interpreted as part of the classroom reward structure. However, several other factors also contributed to the use of computers as a reward; the hardware distribution of 'one computer per classroom', teachers' control over computer access and the technology's associations with 'play'.

Unlike other rewards, such as swimming trips or 'choose time', computers were immediately accessible. They were not placed in a laboratory, which pupils visited only intermittently. They were located permanently in all classrooms, providing an immediate and tangible reward. As Ms Jennings observed, "the computer probably shouldn't be used as a reward, but it's there". Computers were not only immediately accessible. They were also perceived as a 'limited resource', which was a problem for both teachers and pupils. Pupils wanted more time on the computer, while teachers had to find a way of sharing one machine between 30 pupils.

In order to share one computer between a class of pupils, teachers required a system of access. Legislators (DES, 1989) and educational technologists (Papert, 1980) advocate 'free access' to computers in classrooms. In other words, pupils themselves should decide when it is appropriate to use a computer and select software relevant to the task. However, in all but one of the field site classrooms, teachers controlled access to computer activity. Teachers determined who used the computer, when they used it and, to a great extent, teachers also determined which applications pupils used and how they used them. For example, in the case of word processing, teachers usually decided whether pupils should draft straight onto the computer or copy a piece of work from their exercise book, and they also decided what pupils should draft a story about or which piece of work they should copy.

It should be no surprise that teachers control access to computers in classrooms, since they also control access to all other artefacts and learning experiences. This is how teachers direct and influence class activity and ensure that the 'work' of the class is done. The only classroom in which pupils had free access to the computer was Clement nursery, where pupils had free access to all other learning experiences. This was also the only classroom in which the computer did not form part of the punishment-reward system. Teachers only withdrew access to the computer if pupils 'hogged' or 'abused' the machine.

Clement nursery had an entirely different atmosphere to the other classrooms in this study. While pupils in other classes could not leave their seats without permission, pupils in Clement nursery roamed freely around the classroom. They ran, laughed and shouted. With the exception of 'storytime' and 'grouptime', pupils had the freedom to do what they wanted, when they wanted. Pupils themselves decided whether they wanted to paint, play in the sandpit or go on the computer. Teachers were able to give pupils this freedom, because there was little 'work' to be done. There were no stories to be written or sums to be completed, and pupils under the age of five are not affected by National Curriculum legislation (DES, 1989). Learning in the nursery did not focus on 'writing' and 'sums', but on the development of social and motor skills.[57]

In Clement nursery, there was no clear distinction between 'learning' and 'play'. Indeed, teachers described class activity as "learning

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[57]Unlike Clement nursery, pupils at St Catherine's nursery did not have 'free' access to computer activity or other learning activities. Teachers in this nursery saw pre-school education as preparation for later schooling.

through play". However for teachers and pupils in infant and junior classrooms, 'learning' and 'play' were two different activities. Learning was a teacher-directed activity, which involved writing stories and doing sums. Play was a pupil-directed activity which did not begin until learning had finished. Whereas nursery pupils 'played' all day, infant and junior pupils only played at restricted times; at breaktimes, at 'special' times such as the end of term and at 'choose time'.

'Choose time' was the only time that infant and junior pupils were allowed to choose their own class activities. It was also the only time that they were allowed to 'play'. 'Choose time' was usually on Friday afternoons, although occasionally it also took place midweek. However, choosing only ever took place once pupils had finished their 'work'.

> [Choosing's] not a planned thing. Normally on a Friday afternoon, we have it because then it's the end of the week. They all have to finish their work ... Normally on a Friday most people have finished and then it's a free afternoon. You know, they choose to do whatever.
>
> *Ms Prior, Clement infant school*

> [Choosing] is on Friday afternoons while I catch up on readers and kids that haven't finished their work and then occasionally ... if I really want to get everybody finished [with their work] ... I'll just have an afternoon where we all finish the bits that we've got to do and when you've done absolutely everything, then you can choose. So it is occasionally midweek, but normally it's just a Friday afternoon.
>
> *Ms Jennings, Priory Lane primary school*

'Choose time' served a number of different functions. It ensured that the whole class had completed set tasks, it rewarded pupils who had completed their tasks with the opportunity to play, and it kept pupils 'busy' at a time when teachers had had enough of teaching and pupils had had enough of learning.

During 'choose time', pupils played with toys such as Lego, plastacine and building bricks. They also 'played' on the computer. Like 'messing around', 'play' involved the use of adventure games and basic practice exercises. However, it only involved the use of adventure games and basic practice exercises which pupils themselves chose to play; that is, applications which had a 'game-like' quality. These 'games' rated highly as a classroom reward. However, there was one type of application which rated even higher; non-educational computer games of the type which are commonly played outside school. These games were also played during 'choose time'.

In the field site classrooms, all applications which had a game-like quality, including 'educational' applications, carried strong connotations of 'play'. Indeed, basic practice exercises, sorting and matching programs and adventure games were referred to by teachers and pupils simply as 'games'. Applications which had the 'appearance' of games, were perceived and used as games. They were not used for work activity, but for 'messing around' during the last 10 or 20 minutes of a lesson or for play during 'choose time'.

In infant and junior classrooms, learning and play are distinct activities. If pupils use applications which have a game-like quality, they are perceived by other teachers, parents and pupils to be playing rather than learning:

> Interviewer: Do you know what children in other classes do on the computer?
>
> Karen: Some of them. Most of the time the other classes play games on the computer.
>
> Interviewer: How do you know that?
>
> Karen: Because sometimes I go into their classrooms to give their teacher a little message and they usually play games because I look at their computer to see what they're doing and they're playing games.
>
> Interviewer: What do you think about that?
>
> Karen: They shouldn't do it because they're not learning anything except for how to play and they should be learning to write and read.

Excerpt from interview with Karen, aged 6, Mr Holland's class

> If you play a game, parents ... or teachers might think all we're doing is playing games. It appears like a game, so they're playing rather than doing anything educational ... whereas word processing is the most obvious one that's seen as being educational.
>
> *Mr Andrews, Range primary school*

In classrooms, where teachers are employed to 'teach' and pupils go to 'learn', the use of packages with game-like features carries negative connotations. Pupils are seen to be playing rather than learning, and teachers are seen as 'unprofessional'. Television and video were seen similarly and their use was also restricted to 'special' times and 'play' times. Indeed, Cuban (1986: 61) notes that most educational technologies have been "somewhat tainted as teaching tools" by their association with entertainment rather than education.

Television, video and game-like software all carry negative connotations inside classrooms because of the way the technologies are used and perceived outside classrooms. They are technologies which entertain rather than educate. Almost all pupils in the field site classrooms used computer games outside school, and teachers were aware that this influenced perceptions of computers inside school:

> It's hard getting over to [parents] that it's not a games computer ... like last year, at parents evening, I had someone saying "oh, he loves the computer. Do you think it's good for him being on it every night?" and I'm saying "oh yeah, brill, brill. Push it as much as you can" and then the next minute he's saying "ooh he's on level three" and you know Supermario whatever. And I had to double-track back and say "oh God I didn't think you meant that kind of computer" ... I think because [parents] still see [the computer] as a games thing they don't hold it in as much importance as some of the other subjects. I don't think they would connect it with writing and reading skills as much as you might think, just because they see computers as something different really.
>
> *Ms Kerr, St Catherine's primary school*

> So many [pupils] have got these games at home ... parents probably don't see how important [computers] are for life. They probably just see them as games.
>
> *Ms Jennings, Priory Lane primary school*

Given the negative association of computer games with play, it is perhaps surprising that they and other game-like packages are used in classrooms. However, it is *because* of their association with play outside classrooms that 'games' form such a valuable part of the punishment-reward system inside classrooms.

This section has demonstrated that computers were perceived and used in the field site classrooms as artefacts for 'work', 'play' and 'messing around'. Word processing was a 'work' or 'learning' activity, which took place at the same time as other work; that is, writing and sums. In the closed classroom organisation, the product of this activity provided important evidence of learning. Basic practice exercises and adventure games were only used once pupils had finished their work. They were used at the end of a lesson to 'mess around', or at 'choose time' to play. In both instances, the computer functioned as a 'filler' activity and a 'reward'. However, the activities differed in that teachers retained control over computer use during 'messing around', while pupils were allowed to choose their own activities during 'play', a choice which included the use of 'non-educational' computer games.

A theory of classroom computer use

Previous sections of this chapter have described patterns of computer use in the field site classrooms and introduced concepts to explain these patterns. This section summarizes the patterns and establishes links between concepts to build a theoretical explanation of classroom computer use.

This account has identified several basic patterns of computer use:

> Computers were used for word processing, basic practice exercises and adventure games, but not for control activity, database work or programming.

Word processing applications were used to copy-type previously hand-written work rather than to draft work.

Access to computers was inequitable. Bright, well behaved pupils used computers more often than less able, badly behaved pupils.

Word processing was the most frequently used application in classrooms. However, older pupils spent more time word processing than younger pupils.

Basic practice exercises and adventure games accounted for most computer use other than word processing. However, younger pupils spent more time using basic practice exercises and adventure games than older pupils.

Word processing took place alongside other work activity in the classroom (writing stories or doing sums), while adventure games and basic practice exercises only took place once pupils had finished this work; during the last 10 or 20 minutes of a lesson or during 'choose time'.

'Choose time' was the only time that pupils were allowed to choose their own computer activities. It was also the only time that they were allowed to play 'non-educational' computer games.

Word processing generated a tangible product, which was perceived to be important, but basic practice exercises and adventure games did not generate a product.

These patterns of computer use are both surprising and disturbing. National Curriculum legislation (DES, 1989) states that pupils should use a wide range of applications for the development of 'higher order' cognitive skills such as hypothesis-testing and problem solving, yet pupils in the field site classrooms used only a limited range of applications, which focused on the development of basic skills such as spelling and arithmetic. Legislation also states that pupils should use the editing and re-drafting facilities of word processors to improve the quality of their writing (ibid.), yet the editing facilities of the technology were rarely exploited. According to the legislation (ibid.), pupils should decide when it is appropriate to use a computer and select relevant software, yet teachers retained control of these aspects of computer use. Moreover, teachers gave some pupils more access to computers than others.

Despite high levels of resources and support, computers were not used as expected in the field site classrooms. Previous sections of this chapter have begun to suggest why this was the case. They have suggested that computers were used in unexpected ways, because they were interpreted within specific circumstances. This explanation draws on the idea that computer systems are 'interpretively flexible'; that is, they are interpreted or perceived differently in different circumstances (Pinch and Bijker, 1987). Teachers and pupils interpret what computers are, what they are for and what they can do with them within the specific social, technical and physical circumstances which exist in classrooms.

Computers were interpreted within technical circumstances which included a hardware distribution of 'one computer per classroom', and physical circumstances which included the 'closed' classroom organisation of schooling. Both sets of circumstances had a significant influence on the way that computers were interpreted in classrooms and both constitute important explanatory concepts in this account. Other important concepts are grounded in the social circumstances of classrooms, particularly in professional understandings about the work of teaching in these circumstances; the need to maximise effective learning activity, the need to maintain classroom control, the significance of teacher expertise and the significance of paper products.

Teachers' interpretations of computer systems are not only related to circumstances which exist inside individual classrooms, but also to circumstances outside classrooms; that is, to National and LEA computing policy, to understandings about teaching which are shared among teachers, and to understandings about computers which are shared with pupils and parents. Although classrooms are physically 'closed', their boundaries are, in a sense, open.

Classrooms have particularly permeable boundaries. Although teaching and learning activity is visible only to teachers and pupils inside classrooms, they must account for this activity to a large number of people outside classrooms; to headteachers, inspectors and parents. However, this is not the only sense in which classroom boundaries are permeable to outside influences. Teachers and pupils also bring the outside world into the classroom with them. In Strauss's (1978, 1982, 1985) terms, teachers and pupils belong to multiple 'social worlds'. They have 'school lives', in which teachers teach and pupils learn. However, they also have lives outside school with families, friends and acquaintances. Computers feature in these other lives as a medium for entertainment. When teachers and pupils enter the classroom, they do not leave behind their experiences or perceptions of computers in other worlds. They bring these experiences into the classroom with them.

The classroom is as a place where different social worlds meet. Government policy, societal perceptions of computers and teachers' professional values are all worked out in the microcosm of the classroom, a setting with its own unique demands. Teachers interpret computers in ways which secure a viable compromise between the competing demands of these different social worlds. Although the findings of this study appear to demonstrate that government policy has little impact on classroom computer use, it is not the case that policy simply has no influence on practice. Rather, policy is one of a number of different factors which influence the interpretation of computers in classrooms.

When different social worlds intersect, boundary objects are created (Star and Griesemer, 1989). Star and Griesemer (ibid.) developed the concept of 'boundary objects' to describe how people from different social worlds manage the tensions which arise when they work together. Boundary objects allow people to manage these tensions, because they take on different meanings and functions for different groups of people. In this study, the paper product of copy-typing and the phenomenon of classroom noise can be seen as boundary objects. However, these boundary objects do not 'manage' the tensions which arise when different social worlds interact. Instead, they act as a focus for these tensions.

The paper product of copy-typing and the phenomenon of classroom noise acted as a focus for the tensions which arose as a result of the 'closed' classroom organization of schooling. The closed classroom arrangement isolated teachers and pupils in individual classrooms, where they had few sources of information about activity elsewhere in the school. In the absence of other publicly available sources of information about classroom activity, the paper product of copy-typing and the phenomenon of classroom noise took on powerful meanings within communities of teachers and pupils.

The paper product of copy-typing conveyed an important message about the computer activity which took place in classrooms. This product was placed in exercise books and on display, where it provided tangible evidence of a 'learning' activity, whose value was inscribed in National Curriculum legislation. Moreover, the paper product of copy-typing was also open to interpretation as the product of drafting, an activity perceived to be of greater educational value. While the paper product of copy-typing carried positive connotations among teachers and pupils, classroom noise did not. Noise posed a problem for teachers inside classrooms, because it distracted pupils and interfered with learning activity. However, noise took on an even greater significance outside classrooms, as a measure of classroom control and teacher competence.

In classrooms, computers not only took on different meanings and functions within a group of people. They also took on different meanings and functions for individuals. Computers were interpreted and used as 'substitute teachers', as artefacts which 'rewarded' pupils and 'filled time', and as artefacts for 'work', 'messing around' and 'play'. The computer was often many different things to the same teacher. The meanings and functions associated with the technology allowed teachers to manage the conflicting demands of different groups of people; pupils, parents, policy makers, headteachers and inspectors. However, these meanings and functions also allowed teachers to manage competing demands associated with the work of teaching such as the need to maximise effective learning and the need to maintain classroom control.

The particular patterns of computer use observed in the field site classrooms are based on multiple interpretations of computers, which arose within a combination of circumstances both inside and outside the classroom. Since each classroom had just one computer, computing took place alongside other class activity. This placed teachers in a dilemma: If they supervised computer use, they left other pupils in a less effective educational setting and risked classroom control. Teachers therefore interpreted computer use as an unsupervised activity. They reduced their intervention in computer use by carefully controlling various aspects of the activity, such as the type of applications used (word processing, basic practice exercises and adventure games rather than control technology, databases and LOGO) and the way the applications were used (word processing as copy-typing). Teachers also reduced the need for intervention by matching pupils to computer activities by age and ability, by pairing more able pupils with less able pupils and by making physical changes to the technology (e.g., putting upper case letters on lower case keyboards).

However, the use of computers for copy-typing, basic practice exercises and adventure games is not only based on the interpretation of computers as artefacts for unsupervised use. It is also based on the interpretation of computers as artefacts for 'work', 'messing around' and 'play'. Word processing was seen as a 'work' or 'learning' activity, which took place at the same time as other learning activity (writing and sums), while the use of basic practice exercises and adventure games was perceived as 'messing around' or 'play'. These activities only took place once 'work' had finished, during the last 10 or 20 minutes of a lesson or during 'choosing'.

Basic practice exercises and adventure games also functioned as 'filler' activities and 'rewards'. These activities rewarded pupils who had worked hard and behaved well, and kept 'bright' pupils occupied if they finished their work ahead of the rest of the class. Hence, bright, well behaved pupils spent more time using computers than badly behaved, less able pupils. In addition, infant pupils spent more time using basic practice exercises than junior pupils, and junior pupils spent more time using word processing applications than infant pupils. This pattern is related to the perception that older pupils should spend more time 'working' than younger pupils.

The use of computers as 'fillers' and 'rewards' is related to factors both inside and outside classrooms. 'Filler' activities kept bright pupils occupied, allowing teachers to maximise effective learning activity among the rest of the class and to maintain classroom control. However, these activities also 'rewarded' pupils who had finished their work with the opportunity to 'mess around' or 'play'. The interpretation of computers as 'rewards' is based on a number of different factors; the hardware distribution of one computer per classroom, teachers' control over computer access and the interpretation of computers as artefacts for 'play' outside classrooms.

While basic practice exercises and adventure games functioned as 'fillers' and 'rewards', word processing had another important function. It generated a tangible paper product. Within the closed classroom organisation, this product provided vital evidence of learning activity. In a sense, it was the product rather than the process of word processing which counted as 'work'. Moreover, the product of copy-typing activity was open to interpretation as the product of drafting activity. This paper product was itself an artefact with 'interpretive flexibility.

Computers were used in classrooms for copy typing, basic practice exercises and adventure games rather than control work, database work or LOGO programming, because this range of activities represented a viable compromise between the competing demands of multiple social worlds. This range of activities generated evidence of learning or 'work', but also responded to other demands and constraints of the classroom; 'filling time' for bright pupils, 'rewarding' pupils for good work and facilitating unsupervised computer use. In other words, this range of activities satisfied the minimal demands of teachers and pupils, as well as parents and legislators.

This chapter has described patterns of classroom computer use and presented a theory which explains these patterns. The next chapter considers the implications of this theory for our understanding of the phenomenon of human-computer interaction.

Chapter 5: Challenges to the concepts of human-computer interaction

Introduction

This chapter considers the theory outlined in the previous chapter. This theory of classroom computer use has implications in a number of different areas; most obviously, the design of educational technologies and the development of strategies and policies to support the implementation of these technologies. The theory also has important implications for the way that we understand and investigate the phenomenon of human-computer interaction. This is the focus of the current discussion. The implications of the research for the design and implementation of educational technologies are considered elsewhere.[58]

This chapter demonstrates that many of the traditional concepts, dichotomies and assumptions of the fields of Human-Computer Interaction (HCI) and Computer-Supported Co-operative Work (CSCW) are problematical in the context of empirical classroom computer use. It argues that concepts such as the 'human-computer system' and the 'user interface', dichotomies such as design/use and individual/social, and assumptions about the nature of 'work' are untenable in the face of empirical evidence about what people do with computers in classrooms. The chapter begins, however, with a discussion of the significance of the concepts, dichotomies and assumptions which constitute the discourse of HCI and CSCW.

[58] Croft (1992) focuses on the implications of this work for the development of policies and strategies to support the implementation of educational technologies.

The discourse of HCI

Certain concepts, dichotomies and assumptions are central to the field of HCI. They provide a focus for research and development, delineate the boundaries of a new and disparate field and, indeed, legitimate the very existence of an independent field devoted to the study of 'human-computer interaction'. As Cooper and Bowers (1995) observe, the viability of HCI depends on the production and management of new concepts and categories. These concepts shape the problems that HCI addresses, the methods that it deploys, the theories that it develops and the recommendations that it makes.

Two important concepts in the field of HCI are the 'user interface' and the 'user'. The most significant concept is that of the user interface. The user interface is the central focus of HCI. As Cooper and Bowers (ibid.) note, it is "the object that [HCI] aspires to change". The user interface is generally understood as the computer screen and its design (Grudin, 1990). The term gained currency during the early 1980s as interactive terminals became common both in the home and the workplace. At that time, cognitive psychologists (e.g., Card, Moran and Newell, 1983; Norman, 1986) began to assert the importance of screen layout for the functionality of computer systems, arguing that from the point of view of the user, the interface was the computer system. In asserting the importance of the user interface, cognitive psychologists also argued the importance of the user. The 'user' is thus another fundamental concept in the field of HCI: HCI practitioners develop user interfaces for the benefit of the user.

Who is the user? The first users of computer systems were programmers and engineers, who worked directly with the technology (Grudin, 1990). However, these users are not HCI's concern. The HCI community is concerned with non-specialist users of computer systems, such as secretaries, librarians and doctors; in other words, people who use computer systems as part of their everyday work. These users are represented in HCI as being entirely different to earlier, specialist users of the technology (Cooper and Bowers, 1995). Unlike engineers and programmers, these 'users' are represented as helpless individuals, under threat from technology (ibid.). Schneiderman (1987) argues, for example:

> Frustration and anxiety are a part of daily life for many users of computerized information systems. They struggle to learn command languages or menu selection systems that are supposed to help them do their job. Some people encounter such serious cases of computer shock, terminal terror, or network neurosis that they avoid using computerized systems. These electronic-age maladies are growing more common; but help is on the way!
>
> (p v)

HCI practitioners such as Schneiderman (ibid.) argued that they could help confused and anxious users by re-designing the 'user interface', and they claimed that the way to do this was by developing a science of human-computer interaction based on cognitive psychology.

Cognitive psychologists (e.g., Card, Moran and Newell, 1983; Norman, 1986) argued that cognitive psychology was an ideal basis for an applied science of human-computer interaction, because it allowed users to be described in the same way as computers; that is, as information processors. The information-processing view also allowed the human-computer system to be described in terms of just a small number of discrete elements; the computer, the cognitive system of the 'user', and the 'interface' between them.

By describing the human-computer system in terms of a limited number of discrete elements, the information-processing view provides a basis on which to calculate and predict user behaviour (e.g., Card, Moran and Newell, 1983). This has obvious appeal for a solution-focused enterprise such as systems design. However, the description of the human-computer system in terms of discrete elements serves another useful purpose. By treating the 'interface' as a distinct component, separate from the 'computer system', the boundary between HCI and other areas of computer science, such as software engineering, is clearly defined. HCI has an area to call its own,[59] while the functionality of other aspects of the computer system remain the province of the engineer (Bannon, 1994).

As I have already asserted, the 'user', the 'user interface' and the 'human-computer system' are central concepts in the field of HCI. The user interface provides a focus for research and development, the helpless user provides a reason for doing it, and cognitive representations of the human-computer system assert that cognitive psychologists should be the people to do it. As Cooper and Bowers (1995) observe, these concepts are used to justify the need for the field of HCI and assert its legitimacy. However, the significance of the concepts does not end there, for they not only establish the need for HCI, they also shape the work which is done in the name of HCI.

Until recently, the properties and boundaries of theoretical constructs such as the user interface and the human-computer system were taken for granted among the HCI community. However, the recognition of the social influences on computer use has begun to generate debate about the meaning of these concepts (e.g., Winograd and Flores, 1987;

[59]Many HCI texts argue that 'interface design' should be separate from other aspects of design. Norman (1987) argues, for example, "separate the interface design from other programming tasks. Make the interface a separate data module ... interface design should be its own discipline, for it requires sophistication in both programming and human behaviour. If we had proper modularity then the interface designer could modify the interface independently of the rest of the system".

Anderson et al., 1993; Grudin, 1990a). Grudin (1990a) claims, for example, that there is more to the user interface than the computer screen and its design, while Anderson et al. (1993: 1010) argue that the human-computer system needs re-defining to take account of the social influences on computer use:

> When the boundaries of action are defined in terms of the 'natural' boundaries of the interacting systems, namely the computer and the user, it is easy to see where the sub-division should stop. Action takes place between the two. We have three clearly demarcated arenas: the hardware system of the computer, the cognitive system of the user and the interface system which links them ... when we bring a social perspective to bear on the activities in hand, there may be no such natural boundaries for us to model.

Recognition of the social influences on computer use has been strongest within the Computer-Supported Co-operative Work (CSCW) community. The field of CSCW emerged in the late 1980s, fuelled by the spread of network technology and interest in multi-user systems or 'groupware' (Grudin, 1991). Like the field of HCI, CSCW depends for its existence on the production and management of new concepts and categories, which provide a focus for research and development and which delineate the boundaries of the field in relation to HCI. One of the most significant concepts in the field of CSCW is 'groupware'.

Groupware (sometimes referred to as CSCW applications) is to CSCW what the user interface is to HCI. The development of groupware provides a focus for the work of the CSCW community. There is some disagreement within CSCW as to what the concept of groupware actually means (Grudin, 1991). For example, some people regard electronic mail and network file servers as groupware, while others do not (ibid.). However, groupware is generally seen as a class of computer systems which supports co-operative work; that is, work involving two or more users. In this sense, a clear distinction is made between 'groupware' and 'single-user' applications. Single-user applications are seen as HCI's concern, while multi-user applications are the province of CSCW (Hughes, Randall and Shapiro, 1991).

Another key concept in the field of CSCW is the concept of 'co-operative work'. This concept is also interpreted in different ways. Bannon (1994) lists a number of different senses of the term, ranging from work which involves multiple individuals to work which also involves shared goals and motives. Yet, whatever the interpretation of the term, co-operative work is regarded in CSCW as different to the type of work that single-user applications support. Hence, classical HCI is seen as appropriate for the design of systems to support 'individual' work, but not for the development of systems to support co-operative work (Hughes, Randall and Shapiro, 1991). The development of co-operative systems is said to require consideration of the 'sociality' of work. For example, Grudin (1991: 95) argues:

> Social, political and motivational aspects of computer use that can generally be ignored in designing a word processor, programming language, business graphics, or other single-user application are important considerations in designing groupware. The impact of new technology on a group is more difficult to measure and understand than are changes in individual productivity or preference.

There is a clear message in Grudin's (1991) argument that while it is unnecessary to consider 'social' influences in the design of single-user applications, it is essential to consider them in the design of groupware. There is also an implication that the design of groupware requires different techniques and principles to the design of single-user applications. It requires techniques for explicating the social influences on computer use. In other words, the design of groupware requires input from social scientists.

Just as HCI's interest in the 'cognitive' distinguishes it from the field of ergonomics (Cooper and Bowers, 1995; Bannon, 1994), so CSCW's interest in the 'social' marks the boundary between it and HCI. HCI practitioners use techniques based in cognitive psychology to develop computer systems for individual use, while the CSCW community uses techniques based in the social sciences to develop systems for groups. This is not to suggest that there is no interest in the social aspects of computer systems within the field of HCI (cf. Suchman, 1987; Winograd and Flores, 1987; Whiteside et al., 1988) or that the field of CSCW is composed entirely of social scientists using only sociological techniques (cf. Bannon, 1994). However, the dichotomy between the individual and the social is clearly significant to the boundary between HCI and CSCW, just as it is significant to the boundary between the contributing disciplines of psychology and sociology (Hughes, Randall and Shapiro, 1991).

Dichotomies such as individual/social and concepts such as the interface, the user and groupware obviously have an important function within HCI and CSCW, focusing research and development in the fields and legitimating disciplinary boundaries. The problem with these dichotomies and concepts is that they do not necessarily reflect the way that people actually use computer systems. The properties and boundaries implied by these concepts and dichotomies are not 'natural' features of the world. They are impositions upon the world, generated in the discourse of those who build and discuss computer systems (Winograd and Flores, 1987). As Cooper and Bowers (1995: 51) observe with reference to the concept of the user:

> It is not so much that users *are* [original emphasis] angry, frightened, and different from designers, it is more that, for this way of legitimating HCI, they *have to be*[original emphasis]. One would have no case for HCI, if - having focused on users - we found them to be happy, content, familiar and already as warm as Schneiderman wants them to be!

There is currently theoretical debate within both HCI and CSCW about dichotomies such as individual/social (Hughes, Randall and Shapiro,

1991) and concepts such as the user interface (Winograd and Flores, 1987; Grudin, 1990a), the user (Agre, 1995; Bowers, 1994) and the human-computer system (Anderson et al., 1993). However, there has been little empirical investigation of these concepts. Few studies have investigated whether familiar notions of the interface, the user and the human-computer system stand up as 'real world' descriptions of what people do with computer systems. In fact, there has been remarkably little research of any type into real world interactions with computer systems.

Few real world studies of computer use have been carried out within either HCI or CSCW. Most ethnographic studies (e.g., Heath and Luff, 1992; Hughes et al., 1992; Heath et al., 1993) are studies of co-operative work settings, which aim to inform the design of CSCW systems. They are not studies of the use of CSCW or other computer systems. Furthermore, as Nyce and Lowgren (1995) point out, these ethnomethodological studies are more concerned with generating detailed descriptions of work practices than investigating the concepts of human-computer interaction.

Nyce and Lowgren (ibid.: 39) argue that ethnomethodological studies such as Suchman (1987) and Hughes, Randall and Shapiro (1992) reduce ethnography to "just another field technique ... a way to describe (fill in) some set of already predefined categories". They argue that the real value of ethnography for HCI is as a foundational approach, which goes beyond descriptions of work practices to examine the concepts and categories which lie at the heart of HCI. The remaining sections of this chapter do just that. They examine the concepts and dichotomies of HCI and CSCW, and they demonstrate that many of these concepts and dichotomies do not stand up in the light of evidence about what people do with computers in classrooms. The analysis begins with a discussion of the concept of 'work'. The first section considers the relationship between work and other activity, while the following section considers the dichotomy between 'individual' and 'co-operative' work.

'Work' and other activity

As Nyce and Lowgren (1995) observe, the concept of 'work' is central to the enterprise of HCI. Yet, as they (ibid.: 40) also observe, the meaning of 'work' is often taken for granted:

> ... in HCI, the theoretical structures, models and languages we have to talk about ... work are not particularly robust. To put it another way, it seems that common sense (I know what work is) and ideology (e.g., work [and the workplace] should be more democratic, more equalitarian ... whatever), in a word, direct uncritical transfers from cultural to academic discourse, are more responsible for the direction HCI research and development efforts have taken that any sustained analysis.

Work is most often described in HCI in terms of individual 'tasks', such as word processing a document (e.g., Card, Moran and Newell, 1983; Kieras, 1988, Irving, Polson and Irving, 1994). These tasks are themselves broken down into numerous sub-tasks, such as selecting text, typing a word or pressing the delete key. The advantage of models which describe work in terms of discrete tasks and sub-tasks (e.g., Card, Moran and Newell, 1983) is that they generate testable predictions about user performance. The problem with these models is that they consider individual tasks in isolation from both other work tasks and the context in which work takes place.

In recent years, ethnomethodological studies (e.g., Heath and Luff, 1992; Hughes et al., 1992) have begun to generate an understanding of work in context. Instead of breaking work down into isolated tasks and sub-tasks, these studies consider how individual tasks relate to other tasks, carried out within teams of people, and they consider how tasks are situated within specific social, physical and technical settings. Ethnomethodological studies have generated detailed and valuable descriptions of work activities. However, these studies have shed little light on the meaning of work; that is, what 'counts' as work in specific settings and how the appearance of work is produced and recognised. Furthermore, these studies have shed no light on the relationship between work activity and other activity, such as play. In other words, ethnomethodology considers individual work tasks in the context of other work tasks, but it fails to consider work activity in the context of other types of activity.

This failure to appreciate the relationship between work and other types of activity is evident in the long-standing debate within HCI about the transfer of features from computer games to other types of application. It has been suggested by a number of researchers (e.g., Carroll, 1982; Malone, 1984) that intrinsically motivating features of computer games could be used to improve the design of interfaces for applications such as word processors. Malone (1984) suggests, for example, that word processors would be more enjoyable to use if they had different 'levels' or displayed 'scores', while Carroll (1982: 49) also suggests that word processors should be made "more like computer games".

The argument that word processors should be made more like games is not based in a failure to recognise any distinction between the two types of application. Both Carroll (1982) and Malone (1984) note the difference between 'tools' and 'toys', 'work' and 'recreation'. Carroll (1982: 53) observes, "adventure is recreation whereas application systems are work. In our culture, we sharply isolate work from recreation". Yet neither Carroll (ibid.) nor Malone (1984) see this distinction as a barrier to the transfer of features from games to other types of application. Carroll (ibid., 53) argues, "this contrast between work and play should not be viewed as monolithic ... we can see how particular aspects of recreation and work co-exist in complex human activities and experiences and can use that knowledge to structure work environments that are based on the organization of play".

While Carroll (1982) and Malone (1984) argue that features of games could be used to make work applications and activities more like play, Thomas and Macredie (1994) argue that the transfer of game-like features to other types of application is potentially problematic. They argue (ibid.: 137), "attempting to employ techniques and features from games to the design of computer systems will run up against a distinction made by users themselves between work and recreation: it would be problematic to apply techniques from computer-based games into 'work' since they are fundamentally 'recreation'".

The theory of classroom computer use presented here supports Thomas and Macredie's (1994) argument. In the field site classrooms, teachers and pupils made a clear distinction between 'work' and 'play', both in computer activity and other types of activity. Writing, sums and word processing were work, while building Lego models and using adventure games and computer games was play. The two types of activity took place at different times, under different circumstances. Play only began once work had finished.

There are two important points to note here in relation to the idea of applying the features of computer games to word processors. Firstly, 'recreational' computer games were not the only applications which were interpreted in classrooms as 'play'. Adventure games and certain basic practice exercises were also interpreted this way, despite the fact that they were designed for educational rather than recreational purposes. One might have expected these 'educational' applications to be interpreted and used as work. However, part of what made them play was their game-like quality; that is, the intrinsically motivating features that Carroll (1982) and Malone (1984) advocate applying to word processors. On the other hand, part of what made word processing work was the absence of these features, which conveyed a clear message about the seriousness of the activity taking place. In other words, the transfer of game-like features to word processors in classrooms might lead to a re-interpretation of the activity and to patterns of use more akin to those of applications interpreted as play.

Secondly, the interpretation of particular computer activities as work or play depends on circumstance, as does the significance of these interpretations. One can imagine, for example, that word processing might be interpreted differently among journalists working on a newspaper than among manual labourers on a building site, while the use of computer games might carry different connotations for computer game designers than for teachers and pupils in classrooms. Applications with a game-like quality carry negative connotations of play in classrooms, because this is an environment dedicated to learning. Moreover, it is an environment (with the exception of nursery education) in which play forms no part of learning. However, in an environment where play was an accepted part of learning, applications with game-like features might be interpreted differently. Hence, for certain types of application in certain types of setting, the features of computer games could perhaps be incorporated into the design of interfaces. Thomas and Macredie (1994) suggest that the design of software which provides training in the use of 'work' applications is one such situation.

This section has argued that the meaning of 'work' is often taken for granted in the field of HCI. It has argued that both task-oriented and ethnomethodological accounts of work fail to appreciate the 'meaning' of work and its relationship to other types of activity such as play. Moreover, it has demonstrated that the meaning of work depends on the circumstances in which it takes place. The next section also considers the nature of work; more specifically, the dichotomy between 'individual' and 'co-operative' work.

Word processing as a 'co-operative' activity

This section discusses two aspects of the dichotomy between 'individual' and 'co-operative' work in HCI and CSCW; firstly, the idea that the use of applications by groups is subject to 'social' influences, while the use of applications by individuals is not and secondly, the idea that single-user applications and groupware are two distinct types of application. Both aspects of this dichotomy are empirically problematical in the context of classroom computer use.

It has frequently been argued in the field of HCI that it is unnecessary to consider the context of work in the design of single-user applications, such as spreadsheets and word processors (e.g., Card, Moran and Newell, 1983; Rasmussen and Goodstein, 1988). This argument is used to assert the role of cognitive psychologists in the design of such systems. For example, Rasmussen and Goodstein (1988: 176) argue:

> Basically, HCI is concerned with the interaction of users with computers in terms of the syntax of communication languages irrespective of the context of work in which the systems are used, that is of the semantic aspects of work. Clearly this approach is important for the development and optimization of 'application programs' such as word-processors, graphic packages and spreadsheets ... users typically develop a skill of manipulating the interface and the focus of research is therefore on human perceptual-motor abilities. Consequently, such studies are well suited for

laboratory experiments isolated from the complexity of the actual work domain content - i.e., by behaviourist studies (not without reason, the word processor has been called the Skinner-box of HCI).

This argument is also put to use in the field of CSCW. Word processors are used as a 'benchmark' to emphasize the need to consider the context of work in other types of application (e.g., Somerville et al., 1992; Grudin, 1991). That is, CSCW practitioners locate arguments that the design of co-operative systems *does* need to consider social influences in statements which recognise that the design of word processors does not. In other words, the word processor is represented as the archetypal 'individual' and 'context-free' computer system.

In classrooms, however, this image of the word processor breaks down: the use of word processors is clearly influenced by the context of use. Word processors were used for copy-typing in the field site classrooms, because they were interpreted within specific technical, physical and social circumstances; the hardware distribution of one computer per classroom, the 'closed' classroom organisation of schooling and the social practices which evolved to manage computer activity in this setting. Moreover, the use of word processors for copy-typing was not only influenced by the way that pupils, the 'end users', interpreted the technology: it was influenced to a significant extent by the way that teachers interpreted the technology. Teachers interpreted word processing as a copy-typing activity, because this activity facilitated unsupervised computer use, allowing teachers to maximise effective learning activity within the class and reduce the risk to classroom control.[60]

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[60]A later section of this chapter examines the implications of teachers' influence on computer activity for the concept of the 'user'.

Word processing was not only interpreted in classrooms as an unsupervised activity. It was also interpreted as a work activity and, hence, as an activity which should generate a tangible product. Each of these interpretations influenced the use of word processors and, crucially, each of these interpretations was social rather than individual. These interpretations were not specific to individual 'end users', who interacted with the technology: they were *shared* among communities of teachers and pupils. It therefore makes little sense to describe word processing in classrooms as an 'individual' activity. The use of word processors by individual pupils was related to interpretations of the technology which were fundamentally social.

This picture of word processing as a 'social' activity supports arguments by some CSCW practitioners (e.g., Bowers, 1991; Hughes, Randall and Shapiro, 1991) that the distinction between individual and co-operative work is unhelpful. Hughes and colleagues (ibid.: 310) argue, for example:

> ... the notion of co-operative work is a puzzling one, both in the sense of there being a distinctive class of collective work, and of there being a distinctive class of work which is 'helpful' or 'harmonious'. We rather consider that *all* [original emphasis] of work is - i.e. can helpfully be analysed as - socially organised ... it makes no more sense to consider work as 'individual' than to consider language as individual.

Hughes, Randall and Shapiro (ibid.: 320) go on to argue, "it does not make sense to define CSCW in terms of interactions with a system involving more than one user, or by specifying some particular characteristics of the work process, or in relation to a particular class of technology ... CSCW should be viewed as a general shift in the perspective from which computer support systems - *all* [original emphasis] computer support systems - are designed".

The description of computer use in the previous chapter suggests that it makes little sense to describe classroom computer activity as individual or the applications used in classrooms as single-user applications. For example, we have seen that although word processors were often used by individual pupils, they were also used by pairs of pupils. The same was true of adventure games and basic practice exercises, which were occasionally used by as many as 3 or 4 pupils. Each of these applications was designed for individual use, yet each was also used by groups.[61] While one would not necessarily wish to label these applications 'groupware', it is important to recognise that applications designed for individuals were also interpreted in use as applications for groups. How the applications were interpreted depended on particular circumstances, such as whether teachers wanted to 'pair' pupils, and whether adventure games were used for 'messing around' or 'play'. Hence, it was only possible to categorize applications as single-user or co-operative applications at specific times in relation to specific circumstances.

This section has argued that the distinctions between individual and co-operative work, and single-user and co-operative systems, are untenable in classrooms. It has argued that applications in classrooms were used by both individuals and groups. Focusing on the use of word processors, it has also argued that computer use by individual pupils depended on interpretations of the technology which were shared with other pupils and teachers. This section therefore concludes that word processing in classrooms is a fundamentally social activity. The next section considers the implications of this understanding of computer

[61]There is recent evidence to suggest that database use (for example, searching for items in an on-line catalogue in a university library) is also a co-operative rather than individual activity. Although the user interfaces to these databases are designed for individual use, empirical evidence suggests that people cooperate when searching for unknown items (Twidale, 1995).

use for the concepts of the 'user interface' and the 'human-computer system'.

The 'interface' and the 'human-computer system'

The concepts of the 'user interface' (hereafter simply the 'interface') and the 'human-computer system' are central to the field of HCI. The interface provides a focus for work in the field, while cognitive models of the human-computer system (e.g., Card, Moran and Newell, 1983; Norman, 1986) assert the role of cognitive psychologists in this work. Both the interface and the human-computer system are usually represented in HCI as bounded entities (e.g., Card, Moran and Newell, 1983; Woods and Roth, 1988; Barfield, 1993). This section argues, however, that in classrooms, the human-computer system and the interface have no obvious boundaries.

The human-computer system is typically represented in HCI as a 'closed' system, comprising the 'user', the 'computer' and the 'interface' between them (e.g., Card, Moran and Newell, 1983; Kieras, 1988). Interaction within this system is generally described in terms of cognitive processes. The advantages of modelling human-computer interaction as a closed system are obvious: if all elements of the human-computer system can be identified, then it is possible to calculate and predict user performance. Moreover, by describing human-computer interaction in purely cognitive terms, it is possible to formulate general design principles, which are applicable to different types of application in different contexts (e.g., Card, Moran and Newell, 1983). As Woods and Roth (1988: 6) observe, "if each world is seen as unique and must be investigated 'tabula rasa' ... it would impose strong practical constraints on principle-driven development of support systems".

Interaction within the human-computer system is said to take place at the interface (e.g., Card, Moran and Newell, 1983; Reisner, 1987; Barfield, 1993). The interface is generally seen as an identifiable component of the computer system, which comprises the screen, its design and input devices such as the keyboard and mouse (Grudin, 1991). In other words, the interface is seen as a tangible and technical entity, which separates the user from the computer system. As Reisner (1987: 337) puts it, "an interface, by definition, is a common boundary between two sides, the two 'sides' in this case being the computer and the human".

This description of the interface has focused on its location; in other words, what (or where) the interface is. However, there is another aspect to the concept of the 'interface': what the interface does. The interface is seen as the site of human-computer interaction. In traditional HCI (e.g., Card, Moran and Newell, 1983; Norman, 1986), this interaction is viewed as a 'dialogue' between the user and the computer. Card, Moran and Newell (1983: 4) describe this dialogue as follows:

> ... the user and the computer engage in a communicative dialogue whose purpose is the accomplishment of some task. It can be termed a dialogue because both the computer and the user have access to the stream of symbols flowing back and forth to accomplish the communication; each can interrupt, query and correct the communication at various points.

According to this view, communication between the user and the computer takes the form of symbol processing, and efforts to improve this communication should focus on improving the way that the interface presents information to the user. There are, however, other views of the interaction which takes place at the interface.

A number of researchers (e.g., Winograd and Flores, 1987; Grudin, 1990) have argued that interaction at the interface is shaped by factors which lie outside the traditional boundaries of the human-computer system. Grudin (1990) argues, for example, that users' interactions with computer systems are shaped by organizational factors such as training, documentation and interaction with consultants and colleagues. He states (ibid.: 271):

> These artefacts, processes, and people are so significant in shaping our interaction with the computer that it is myopic not to see them as part of a user's interface to the computer.

Grudin (ibid.) emphasizes that HCI research should widen its focus beyond conventional ideas of the interface to understand all the different factors which shape people's interactions with computer systems. In other words, he argues that our understanding of the interface should be based on empirical observations of how people actually relate to computer systems. Bannon and Bodker (quoted in Bowers and Rodden, 1993) make a similar point. They argue, "perhaps the very concept of HCI as a distinct topic or discipline concerned with user interfaces needs to be re-thought, and emphasis moved from surface similarities of systems, in terms of interaction style, to understanding their use!".

Bowers and Rodden (1993) report on an empirical study, which did try to understand the concept of the interface in terms of computer use. Their study of the implementation of a CSCW network found that users of the network talked about and related to the system in a number of different ways: economically (in terms of the amount of money that had been invested in the system), politically (in terms of changes to the balance of power within the organization) and organizationally (in terms of changes to organizational communication). Hence, Bowers and Rodden (ibid.) argue that the accepted notion of the 'interface' is problematic as a model of people's real world interactions with computer systems. They conclude that computer systems have not one, but many different interfaces.

As the previous chapter demonstrated, the conventional idea of the interface is also problematic as a description of interactions with computer systems in classrooms. This model of human-computer interaction is deficient in three basic respects: first, the idea that users have just one interface to or relationship with a computer; second, the idea that this interface or relationship is software-controlled (that is, determined by the arrangement of information on a computer screen) and third, the idea that this interface or relationship is individual rather than social.

Teachers and pupils in this study had many different 'interfaces' to the computer. That is, they interpreted the computer in multiple ways. The computer was an artefact for both work and play. However, it was also an artefact which kept pupils busy, motivated them to appropriate learning behaviour and 'rewarded' them for good behaviour. In other words, the computer was interpreted by teachers as an artefact for solving a variety of problems related to the enterprise of teaching. Patterns of classroom computer use cannot be explained in terms of a single interface between teachers, pupils and computer systems. These patterns are based on multiple interpretations of the technology.

Teachers and pupils not only had several different interfaces to the computer. They also had several different interfaces to individual applications. That is, they interpreted the same software 'interface' in multiple ways. For example, individual adventure games were interpreted by teachers as artefacts for both play and messing around, and as artefacts which both rewarded pupils and kept them busy. These multiple interpretations were not determined by a particular configuration of information on screen. They arose within specific social, technical and physical circumstances. This is not to say that the 'appearance' of the software 'interface' was unimportant to these interpretations. On the contrary, it was crucial. This is demonstrated by the interpretation of basic practice exercises with game-like features as 'play' rather than 'work'. However, the significance of these game-like features is context-specific: applications with game-like features are interpreted in classrooms as play because the classroom is an environment dedicated to learning, where learning and play are seen as mutually exclusive activities.

Interfaces to computers in classrooms are fundamentally social. Teachers and pupils did not relate to computers in individual and idiosyncratic ways. Their interpretations were shared with other teachers, pupils and parents. Moreover, interpretations of computers inside classrooms were also related to interpretations of the technology outside classrooms. Teachers and pupils brought their experiences of computers in other social worlds into the classroom with them.

This raises the question of exactly where the boundaries of the interface and the human-computer system lie. Interactions with computers in classrooms cannot be fully explained by drawing a boundary around the computer, the cognitive system of an individual user and the interface between them, neither can they be explained by drawing a boundary around the computer system, the shared interpretations of pupils and teachers and circumstances within 'closed' classrooms. There are no 'natural' boundaries to the interface or the human-computer system in classrooms. In the words of Anderson et al. (1993: 1011), they are "systems without bounds".

This section has argued that conventional notions of the interface and the human-computer system are untenable as descriptions of interactions with computers in classrooms. This argument is based on three main observations. First, teachers and pupils relate to computers in multiple ways. In other words, there is no one 'interface'. Second, these relationships are social, rather than individual, and last, these relationships are influenced by numerous factors both inside and outside classrooms. This section therefore concludes that no clear boundaries can be drawn around the 'interface' or the 'human-computer system' in classrooms.

The next section examines the concept of the 'user' in HCI. It argues that the conventional understanding of the user is deficient in two basic respects in relation to classroom computer use: the idea that users are always 'end users', who interact directly with the technology and the idea that 'users' are passive recipients of computer systems, who either accept or reject the technology. The next section argues that both teachers and pupils are users of computer systems in classrooms. Furthermore, it argues that these users are not passive recipients of the technology, but active 'designers' of it.

'Users' and 'designers'

The 'user' is typically represented in HCI as someone who interacts directly with the computer (e.g., Card, Moran and Newell, 1983; Kieras, 1988; Gong and Kieras, 1994). In other words, the user is seen as the 'end user', the person who uses the computer in their work. According to this view, someone word processing a report is a user, but the person for whom the report is intended is not. To give another example, a bank clerk processing a customer query by computer is a user, but the customer is not.

Users are generally represented in HCI as isolated individuals. Cognitive models such as GOMS (e.g., Card, Moran and Newell, 1983; Kieras, 1988; Gong and Kieras, 1994) reduce human-computer interaction to interaction between a single user and the computer. The advantage of drawing a fixed boundary around the human-computer system is the ability to calculate and predict user performance. The disadvantage of this boundary is that it isolates the user in an artificial vacuum and fails to recognise the significance of 'individual' computer activity in its wider social context. Hence, models such as GOMS recognise that individual users undertake tasks, but fail to consider why they undertake them, on whose behalf and in co-operation with whom.

Individual users also tend to be represented in HCI as passive recipients of computer systems (e.g., Schneiderman, 1987; Carroll, 1987). They are portrayed as 'helpless' victims of technological advance, under siege by the designers of computer systems (Cooper and Bowers, 1995). Users may either 'accept' or 'resist' computer systems (Mackie and Wylie, 1988), but there is little recognition that users actually adapt or alter the technology. There is little recognition that users play any part in interpreting what computers are, what they are for and what they can do with them. Indeed, Mumford (quoted in Agre, 1995) observes that if users do interpret computer systems in ways unintended by designers, designers often characterise this use as 'resistance' to the technology.

However, as Cooper and Bowers (1995) note, users are not necessarily 'helpless' in their relationship to computer systems. Rather, this is the way that the field of HCI represents them. In classrooms, users were far from 'helpless' in their interactions with technology: they were active in the process of interpreting what computer systems were and what they could do with them. Teachers and pupils constructed the technology both socially and physically in use. They constructed computer systems socially through their multiple interpretations of the technology (as work, play, fillers and rewards), and they constructed computer systems physically by placing upper case letters on lower case keyboards or by disabling problematic peripheral devices such as printers and mice.

Design is usually thought of as a process which ends when computer systems leave the laboratory. However, we can argue that the design process does not end, but instead changes hands. Design is not only a physical process: it is a social process, which continues during the implementation and use of computer systems.[62] Computer systems are designed and re-designed by users in specific circumstances. For example, word processors were designed by software engineers as tools for the flexible creation of texts. However, they were re-designed in classrooms as typewriters. Teachers re-designed the technology this way, because they interpreted computers as artefacts for unsupervised use and they perceived copy-typing to require less supervision than drafting.

Although word processors were re-designed as typewriters in the field site classrooms, they might have been interpreted differently in other classroom circumstances. These teachers re-designed word processors as typewriters in order to secure conditions which they and their colleagues regarded as essential to the work of teaching; that is, maximum class attention to learning tasks and the appearance of classroom control, conveyed within the closed classroom organization as a low level of classroom noise. However, had the schools been

[62]See Bowers and Pycock (1994) for a discussion of design in the laboratory as a social process.

organized differently and had noisy pupils not carried connotations of a lack of control and a lack of teacher competence, the technology might have been interpreted and used differently.

Hence, computer systems are interpreted within specific classroom circumstances and, should those circumstances change, the technology may be re-interpreted. In other words, classroom computer systems are in principle open to continual re-design. This suggests that design, implementation and use are not, in fact, distinct phases of the lifecycle of computer systems and that to fully understand design, one needs to look closely at what people actually do with computer systems.

Although pupils were the 'end users' of computer systems in classrooms, teachers were also active in the process of interpreting what computers were for and how they should be used. Teachers determined which pupils used computers, when they used them and how they used them. Furthermore, teachers interpreted computers in ways which met personal concerns related to the enterprise of teaching (as fillers and rewards, for example). It makes little sense to label only pupils as computer users in classrooms. In order to understand how pupils use computers, one has to understand what teachers do with the technology.

This section has argued that the concept of the 'user' as an isolated 'end user' is of little help in understanding how computers are used in classrooms. It has argued that teachers, as well as pupils, should be understood as 'users'. This section has also argued that teachers and pupils are not passive recipients of computer systems, but active interpreters of the technology. This section therefore concludes that design is not a process which ends in the laboratory. It is a process which continues in classrooms.

The Key to Design is Use

> In asking what computers can do, we are drawn into asking what people do with them, and in the end into addressing the fundamental question of what it means to be human.
>
> (Winograd and Flores, 1987: 7)

This chapter has examined some of the concepts and dichotomies, which lie at the heart of HCI. These concepts and dichotomies provide a focus for research and development in the field, delineate disciplinary boundaries and, indeed, legitimate the very existence of an independent field devoted to the study of human-computer interaction. Yet more importantly, these concepts and dichotomies shape the phenomena which are investigated in the name of HCI, the methods which are used to investigate them and the understanding of human-computer interaction which is generated. In other words, these concepts and dichotomies shape the design of computer systems.

The design of computer systems is based in what Winograd and Flores (1987) term the 'rationalistic' tradition. This tradition values certainty and objectivity. Systems are designed for specific purposes, to be used in specific ways. They are based on formal representations of the world, which describe phenomena in terms of small numbers of variables that can be manipulated to make predictions about system behaviour. Cognitive psychologists (e.g., Card, Moran and Newell, 1983; Norman, 1986) have provided an understanding of human-computer interaction which follows this tradition. By drawing rigid boundaries around entities like the 'human-computer system', the 'interface' and the 'user', their formal accounts of human-computer interaction provide the certainty and predictability sought by systems designers. The problem, however, is that real world computer use does not respect the boundaries, dichotomies and certainties implied by these formal models.

Teachers and pupils in this study did not have a single, individual interface to the computer: they had multiple, social interfaces to the technology. These interfaces were not determined by the arrangement of information on a computer screen. They arose within a complex system of technical, physical and social circumstances: the hardware distribution of one computer per classroom, the 'closed' classroom organization of schooling and the social practices which evolved to manage computer use and other activity in this setting. Furthermore, these 'interfaces' to the technology were not only influenced by factors within the classroom setting, but also by interactions with and interpretations of computers outside classrooms.

The interpretation of computer systems within this complex socio-technical system led to some unexpected uses of the technology. Pupils did not have 'free' access to computers. Instead, computers were used as 'filler' activities and 'rewards'. Word processors were not used as flexible tools for creative writing. They were used to copy-type previously hand-written work. Furthermore, 'educational' adventure programs and basic practice exercises were not interpreted as 'learning' activities. They were interpreted and used as games.

Teachers and pupils used computer systems in unexpected ways because they interpreted what computers were, what they were for and what they could do with them within specific classroom circumstances. That is, they re-designed the technology in use. This finding has important implications for systems design. If people re-design computer systems in use, then the design of systems is never 'fixed'. If systems are designed by users within specific circumstances then, should those circumstances change, they may be re-designed. In other words, computer systems are open to continual re-design throughout their implementation and use.

This study of computer use was undertaken with the aim of informing the design of computer systems. Indeed, the author adopted an explicitly theoretical approach to ethnography with the intention of drawing conclusions and making design recommendations. Yet having generated a theory of computer use, the author finds that she has no clear set of principles with which to inform design. Instead, she finds that she generated a complex and context-specific theory, which suggests that, in fact, computer use *is* design.

This research has generated a theory of computer use in just one specific setting. It merely scratches the surface of the complexity of real world human-computer interaction. Yet this one theory reveals quite clearly the inadequacy of existing models and concepts of human-computer interaction. These models and concepts do not do justice to the complexity of real world interactions with computer systems. Herein lies a problem.

Computers are tools for human use. We cannot build useful and usable computer systems without understanding how people use them in complex, everyday situations. As Winograd and Flores (1987: 143) observe in their essay on the philosophical foundations of systems design (ibid.: 143), there is one basic question to which designers must always return, "'What can people do with computers?' and, to begin with, 'what do people do?'". A science of human-computer interaction should be grounded in an understanding of what people do with computer systems in the everyday situations in which they use them. Yet we know remarkably little about this phenomenon.

While ethnomethodological studies (e.g., Suchman, 1987; Heath and Luff, 1992; Hughes, Randall and Shapiro, 1992; Heath et al., 1993) have provided valuable descriptions of work practices to inform the design of computer systems, they tell us little about how people actually use computer systems. Furthermore, ethnomethodological studies have generated an understanding of work practices in settings which suit the aims of its particular approach: highly constrained, 'control room' type settings. Ethnomethodology has not contributed greatly to our understanding of computer use in complex organizational settings, nor is it clear that this approach has the potential to make such a contribution.

The field of HCI must begin to generate an understanding of computer use in the complex, real world situations in which most computer use takes place: in homes, offices, factories, shops and libraries. It needs methodologies which are appropriate for this specific purpose. In other words, it needs a new direction in the 'turn to the social'. This research suggests one possible direction.

Conclusion

The previous chapter concluded that existing models and concepts of human-computer interaction are untenable as descriptions of interactions with computer systems in classrooms, and it argued that the field of HCI should generate an empirical understanding of what people actually do with computer systems in complex, real world situations. In order to do this, the field of HCI must develop methods for investigating computer use in complex organizations.

While ethnomethodology has provided valuable insights into the 'situated' and collaborative nature of human activity in highly constrained settings (e.g., Heath and Luff, 1992; Hughes et al., 1992), it is less suitable for the study of computer use in more complex organizations. Ethnomethodology focuses on interactions within small groups of people in 'closed' settings. Yet complex organizations such as schools, factories and offices constitute multiple groups of people, who interact with each other and with groups outside the organization.

This thesis has presented a 'hybrid' methodology for the study of human-computer interaction in complex organizations. This hybrid is based on four different approaches to social activity: social constructivism (Pinch and Bijker, 1987), grounded theory (Glaser and Strauss, 1967), social worlds theory (Strauss, 1978) and ethnomethodology (Garfinkel, 1967). None of these approaches is appropriate for the study of human-computer interaction in its 'strong' form, so the hybrid methodology borrows some aspects of each approach and rejects others. The result is a hybrid which has greater potential than any of the pure approaches

Unlike ethnomethodology, the hybrid approach has an explicit commitment to theory generation. This commitment is based in the grounded theory method (Glaser and Strauss, 1967). Yet while the hybrid draws on the basic principles of grounded theory, it rejects the approach's ontological and epistemological assumptions. Theory in the hybrid is a 'weak' form of explanation, which embodies explicit theories of causality, but makes no claim to represent reality.

The hybrid also draws on concepts from the Social Construction of Technology (SCOT), particularly the idea of 'interpretive flexibility' (Pinch and Bijker, 1987). That is, the idea that computer systems have different meanings for different people. The idea of 'interpretive flexibility' has generally been applied to the design of technology. However, this idea is extended in the hybrid to examine how computer systems are interpreted in use. In other words, the concept is extended to look at the actual acts and practices through which computer systems are interpreted.

Although the SCOT concept of 'interpretive flexibility' is incorporated into the hybrid methodology, the idea of 'closure' is rejected (Pinch and Bijker, 1987). Closure refers to a process of stabilization, whereby artefacts begin to lose their 'interpretive flexibility' and are taken for granted. However, it makes little sense to suggest that computer systems lose their interpretive flexibility. Although computer systems may sometimes appear to be stable, the potential for re-interpretation always exists.

The SCOT concept of 'relevant social groups' is also rejected as inappropriate for understanding computer use in complex organizations. Pinch and Bijker (1987) define relevant social groups as groups for which a technology has some relevance and for which all members share the same set of meanings attached to a specific artefact. In other words, they represent groups as homogeneous and mutually exclusive units. However, Strauss's (1978) work on social worlds theory suggests that this framework is too simplistic to account for interaction between groups.

Strauss (ibid.) argues that groups and organizations have fuzzy, porous boundaries. Organizations do not exist in isolation: they are situated in a wider arena of multiple social worlds, in which they interact with other groups and organizations. Since groups and organizations have porous boundaries, the way that computers are interpreted and used in one group may influence the way that computers are interpreted and used in other groups.

The hybrid approach also draws on the idea of boundary objects (Star and Griesemer, 1989). Star and Griesemer (ibid.) use the term 'boundary object' to describe objects which are created to manage the tensions which arise when different social worlds interact. However, in classrooms, boundary objects were not created to manage tensions. They became a focus for tensions in the absence of other publicly available sources of information about activity within the 'closed' classroom organization.

This research found that computers were used in classrooms in unexpected and ineffective ways. Previous studies of classroom computer use had also revealed patterns of ineffective computer use, but they had explained these patterns in terms of a lack of training and resources. However, the field site classrooms were among the best equipped and supported primary schools in the country. These patterns cannot be explained simply in terms of a lack of resources. This thesis argues that the patterns were based on multiple interpretations of computer systems which arose within specific classroom circumstances.

This study has demonstrated that teachers and pupils interpreted computers within the specific technical, physical and social circumstances which existed in classrooms. These circumstances included a hardware distribution of one computer per classroom, the closed classroom organization of schooling and the social practices which evolved to manage computer use within this setting. Computers were interpreted within these circumstances as artefacts for work and play, as artefacts for unsupervised use, and as fillers and rewards. Patterns of classroom computer use were grounded in these multiple interpretations of the technology.

This research has also demonstrated that computer use inside classrooms was influenced by interpretations of and interactions with computer systems outside classrooms. The interpretation of computers as artefacts for play inside classrooms related to the widespread use of computer games outside classrooms. Teachers and pupils brought their experiences of computer games into the classroom with them.

This thesis has demonstrated that the concepts of human-computer interaction are untenable as descriptions of interactions with computer systems in classrooms. Teachers and pupils did not have a single, individual interface to the computer. They had multiple, social interfaces to the technology. Moreover, these interfaces or relationships were not determined by the way that information was arranged on screen. They arose within a complex system of technical, physical and social circumstances.

Although pupils were the 'end users' of computer systems in classrooms, teachers were also active in the process of interpreting what computers were for and how they should be used. Teachers interpreted computer systems in ways which met personal concerns related to the work of teaching. This thesis therefore argues that teachers, as well as pupils, should be understood as 'users' in classrooms.

Computers are used in unexpected ways in real world settings because people re-design them in use. People re-design computer systems in ways which do not respect the concepts and dichotomies of HCI. Only if we investigate these concepts empirically, will we begin to understand the boundaries and dimensions of human-computer interaction.

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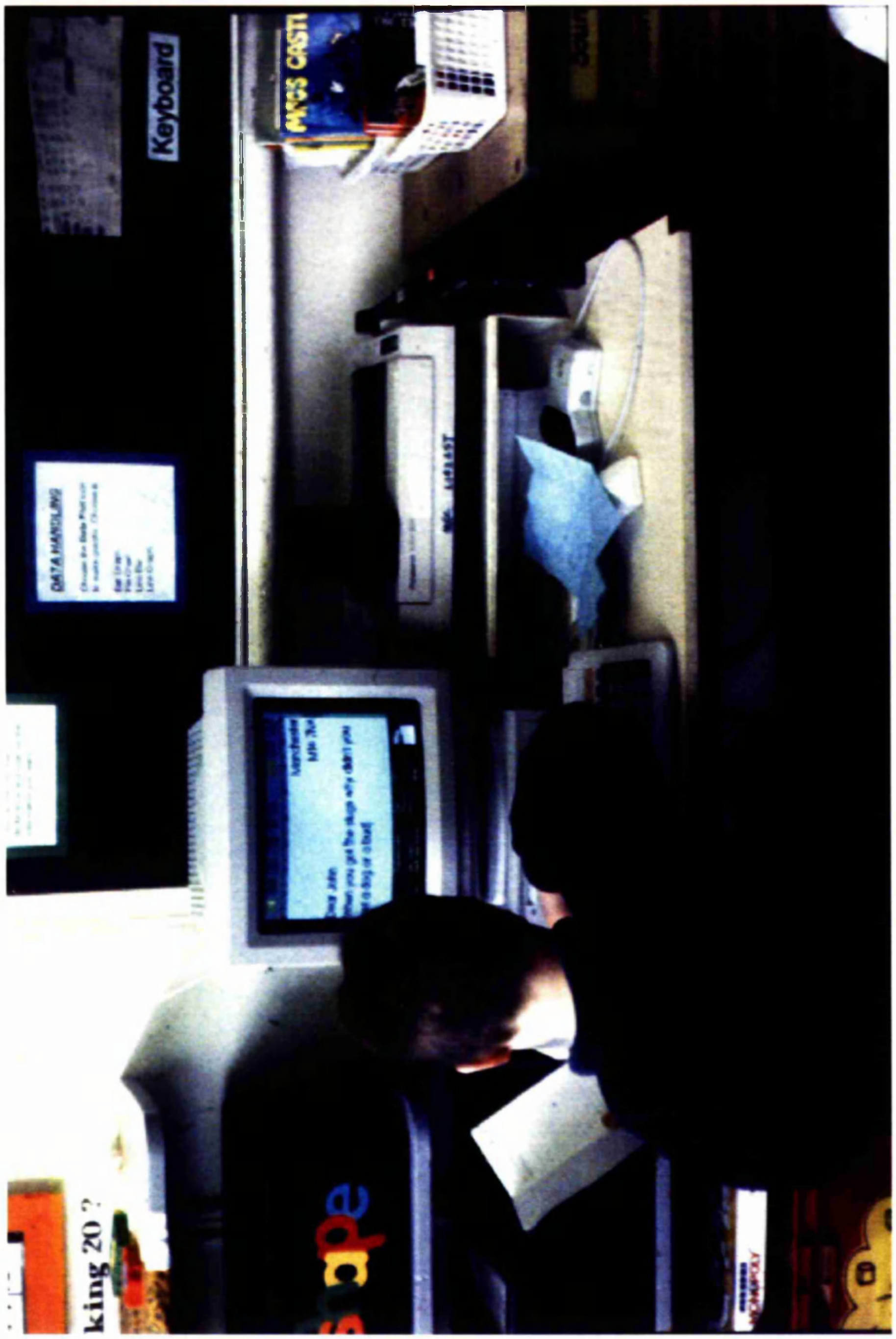
Appendix A: A Pupil Copy-typing

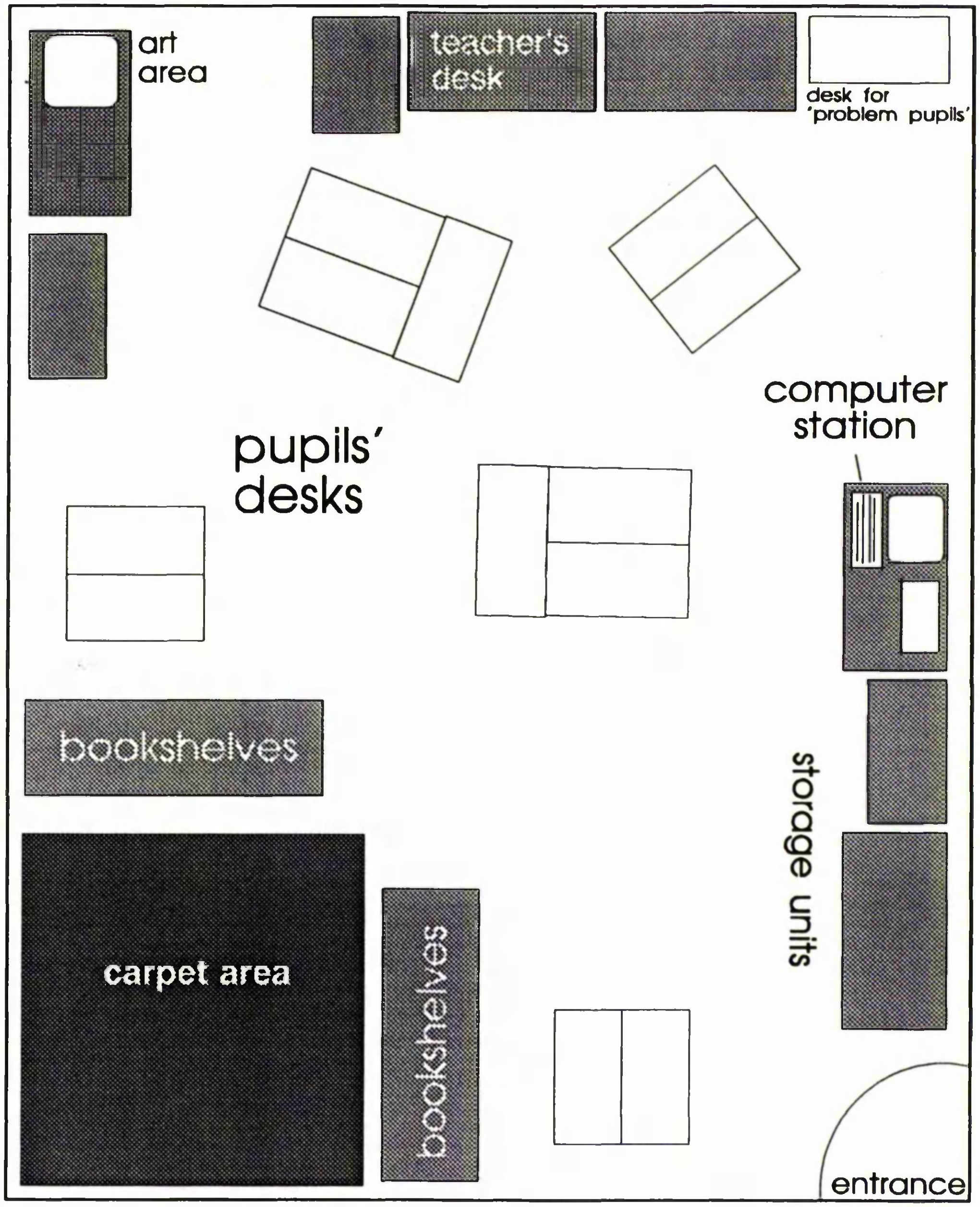


This photograph shows a pupil copying a previously hand-written piece of work. The pupil is using a word processing package called 'Write' on an IBM-compatible computer. The photograph was taken in Ms Prior's classroom at Clement infant school.

Appendix B: Copy-typing in the Context of the Classroom

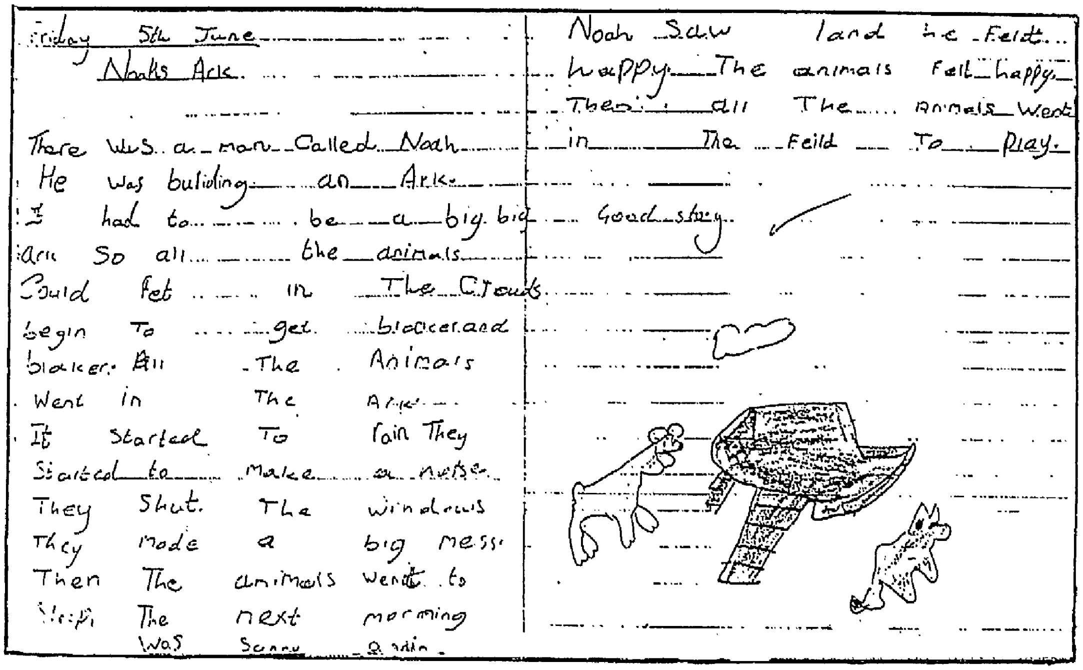
This photograph shows a pupil (the same pupil as is pictured in Appendix A) copy-typing a piece of previously hand-written work at the Computer Station while the teacher attends to pupils who are engaged in other activity. This picture was also taken in Ms Prior's classroom at Clement infant school.

Appendix C: Plan of a Classroom



This is a plan of Ms Prior's classroom, Clement infant school. The computer is situated in a central location, which can be monitored from other parts of the classroom and from which the rest of the classroom is visible.

Appendix D: Examples of Copy-typed Work



Noahs ark

There was a man called
Noah. He was buliding an
Ark. It had to be a big
big ark so all the
animals could fit in. The
clouds begin to get
blacker and blacker. All
the animals went in the ark.
It started to rain.
They started to make a
noise they shut the
winows they made a big
mess. Then the animals went
to sleep the next
morning it was sunny again
Noah saw land he felt
happy. The animals felt
happy then all the animals went
in the field to play.

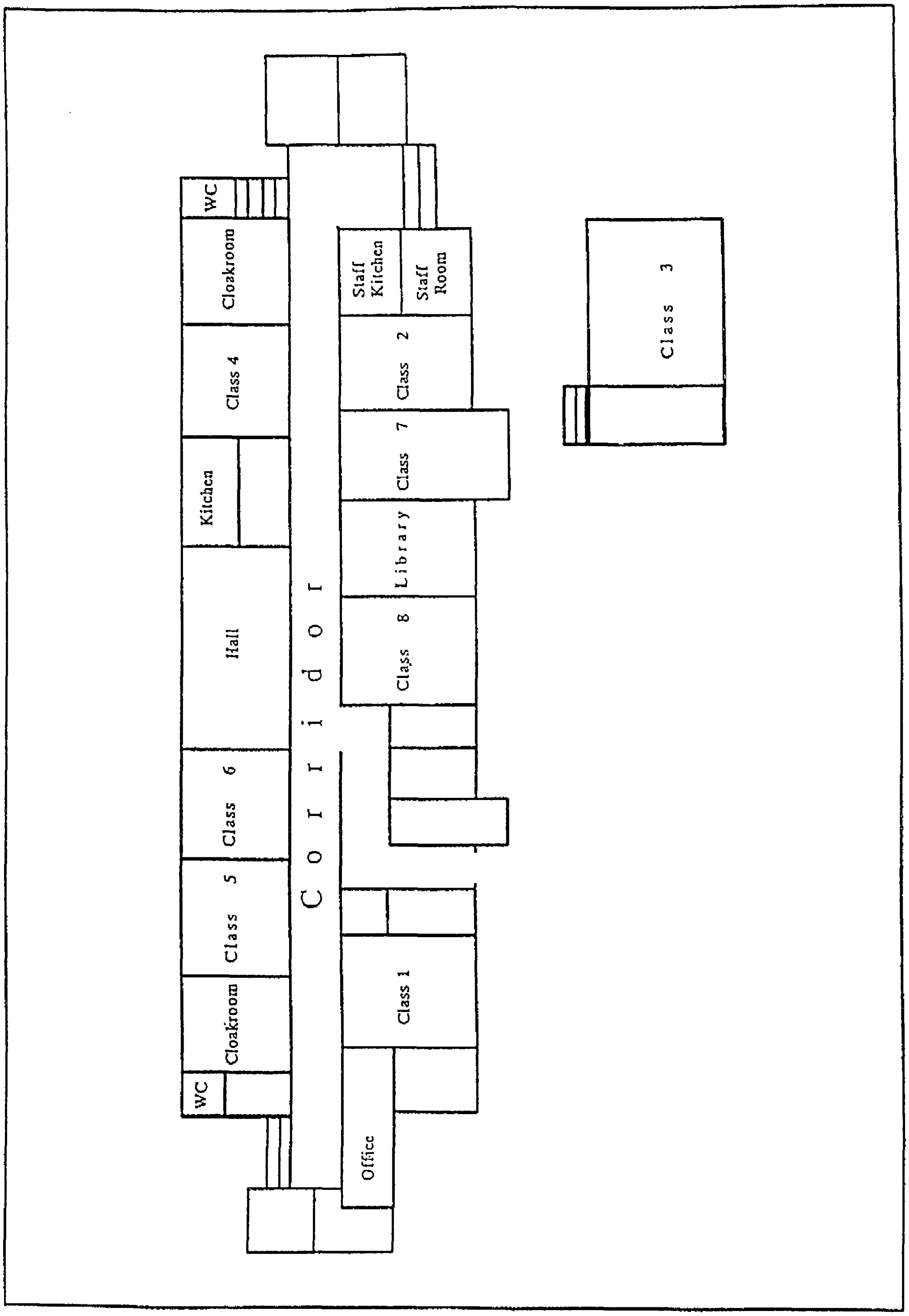
This piece of work and the work overleaf were copy-typed by individual pupils (aged 7) in Mr Andrew's class at Range primary school. The print-outs were then stuck in the pupils' exercise books next to the original hand-written piece.

Wednesday 17th June
A book review.
A review The frog prince
by Cliff moon I read a book
Called The Frog Prince
I enjoyed it very much I
thaught it was exiting and funny
I character I liked most was called
The Frog who was A Princess
one of the best t

A Book Review

A review The Frog Prince
by Cliff Moon. I read a
book called The Frog Prince
.I enjoyed it very. much. I
though it was exciting and
funny. The character I liked
most was called the frog who was
A prince.

Appendix E: Plan of the 'Closed' Classroom Organization



This is a plan of Clement Infant School. It illustrates the 'closed' classroom organization of schooling, in which rectangular, self-contained classrooms lead off a long corridor.

Appendix F: Schedules for Semi-structured Interviews With Teachers and Pupils

Questions for teachers

When did you first encounter computers?

Do you use computers outside school?

How do you feel about computers generally?

Could you tell me how long you've been teaching?

In this particular school?

What have you had in the way of computer training either during teacher training or since you've been teaching?

Would you like more computer training?

Would you be happy for someone to come in and train your pupils to use a new package or are you happier to get the training yourself?

Are there any particular pupils in your class that you and other pupils might ask about computer problems?

How do you feel about using packages that you're not familiar with in the classroom?

How do you feel about having a computer in the classroom (do you see it as something postitive or negative) Why?

In what ways is it useful to you to have a computer in the classroom?

Does it cause any difficulties (extra work/ classroom management difficulties)?

What are the main problems that you have when pupils are using the computer in the classroom?

What happens then? Are there problems that you can deal with on the spot and others that might have to wait? What can/can't you deal with on the spot. Why?

Do you find it difficult to supervise computer use? Why? What happens if you do or if you go over to solve a problem?

Are you able to monitor activity at the computer? What signals tell you that you need to intervene?

Are there any things that you do to lessen the chance that you'll have to go over to the computer to sort things out?

What do you mostly use the computer for in the classroom? Why?

What are the most important things for you when you're choosing something for pupils to use in the classroom?

Do you have particular aims for computer use in the classroom?

Word processing seems to be something that's used a lot. I'm wondering why that is?

Is it something that fits into your curriculum?

Does it fit in with the way children learn to write or does it change anything?

When pupils are using a word processor, do you tend to get them to write straight on to the computer or to write something in their books first? Why?

What happens if pupils write straight on to the computer?

Are there other things that you'd like to use the computer for in class that you're not able to at the moment?

What are the barriers to you doing that at the moment?

How do you decide who goes on the computer when?

Do you tend to have pupils working on their own or in pairs? Why?

Do you find that you're able to do more/different computer work with some classes than others?

What sort of things affect the type of computer work that you're able to do with a class?

Does the computer get used differently in the class at different times of the day? Would pupils be likely to do different things in the morning to the afternoon. Why?

What about at different times of the term?

Do you ever use TV or video. When do you tend to use them?

Do pupils ever use computer games in the class? When?

Are there times when computer use is more about play and times when it's more about work?

Do you know much about how teachers in other classrooms in the school are using computers? How are you made aware of the way they're using computers?

Do you find that other people are interested in the way you're using computers in the classroom? Who might be interested?
What sort of feedback do you get from parents about computer work?

How do you convey to people the work that pupils are doing?

When pupils use the computer is it important that it results in a 'product'? Is it important for all computer activities to result in a product or just some of them?

Could you tell me about how you've organised your classroom in terms of its physical organisation (what areas it might be divided up into, where you seat pupils)?

Where do you normally have the computer?

Why do you have it there (lack of plugs, space, away from particular pupils, where you can see it)?

If plugs weren't issue, where would you ideally put it?

Do you find that pupils near the computer are distracted by it or tend to mess with it?

Would you like to have more computers in the classroom? Why?

How would you feel about having the computers in a different room? Going to a computer 'lab' with lots of computers in it, for example?

Does national curriculum policy influence the way you use computers in the classroom. If so, how?

Questions for pupils

What's your name?

How old are you?

What do you think about computers? What are they for? What can you do with them? Do you like them? What do you like about them?

Do you talk to your friends about computers? What do they think about them? Do you and your friends use use computers outside school? What do you use them for?

What do your mum and dad think about you playing games?

When do you get to go on the computer in school?

What do you use computers for in school?

What do you like doing best on the computer - what would you like to be able to do all the time on the computer? Why?

What other things do you like doing in school - not computers?

Do you ever use computer games in school? When?

If you go on the computer in the morning what do you normally do on it? And in the afternoon? Why is that?

Do you ever watch TV or a video in school? When?

How is using computer games different from writing on the computer?

Are there some things you do on the computer that are 'work' and some things that are 'play'?

What's it like when you write on the computer? Is it different from writing in your book?

Do you wish there were more computers in your class? Why?

Do your mum or dad or your brothers or sisters know what you do on the computer in school?

How do they know that? Do you ever take work home to show them?

Would you like to take computer work home to show them?

Do your friends know what you do on the computer in class? How do they know that?

Do you like getting a print-out - why?

Would you like to get a print out when you do other things on the computer?

Do you know what your friends do on the computer in their classes? How

When you're working on the computer in class is there anything that's difficult/hard?

What do you do if you have problems?

Do you ask for help? Who do you ask?

Does the teacher come and help? When can/can't she come and help? Why can't she come and help sometimes?

What do you think about teachers? What are they like?

Does the computer in the class always get used or are there some times when it doesn't?

Is where you sit in the class near to the computer? Do you ever get distracted by the computer? Is it noisy?

Could you tell me a bit about this computer? What the different bits of it are and what you do with them?