

Technology and medical practice

Christian Heath, Paul Luff and
Marcus Sanchez Svensson

Work, Interaction & Technology Group, King's College London

Abstract One of the most significant developments in healthcare over the past 25 years has been the widespread deployment of information and communication technologies. These technologies have had a wide-ranging impact on the organisation of healthcare, on professional practice and on patients' experience of illness and its management. In this paper we discuss the ways in which *Sociology of Health and Illness* has provided a forum for the analysis of these new technologies in healthcare. We review a range of relevant research published in the Journal; papers that address such issues as dehumanisation and emotional labour, professional practice and identity, and the social and institutional shaping of technology. Despite these important initiatives, we suggest that information and communication technologies in healthcare remain relatively under-explored within the Journal and, more generally, by the sociology of health and illness and point to developments in cognate areas which may have some bearing upon the analysis of technology in action.

Keywords: technology, work, social interaction, organisations

Management were misguided or naive in believing that computer systems in themselves could bring about [such] changes in human practices. Experience in many different environments proves that computer systems cannot influence change in this way. They can only assist in the process and any attempt to force change through the introduction of a system with the characteristics of an operational 'straight jacket' would be potentially doomed to failure (London Ambulance Service Inquiry Report (Page *et al.* 1993: 40)).

That's a funny kind of thing, in which each new object becomes the occasion for seeing again what we see anywhere; seeing people's nastinesses or goodnesses and all the rest, when they do this initially

technical job of talking over the phone. The technical apparatus is, then, being made at home with the rest of our world. And that's a thing that's routinely being done, and it's the source for the failures of technocratic dreams that if only we introduced some fantastic new communication machine the world will be transformed. Where what happens is that the object is made at home in the world that has whatever organisation it already has (Sacks 1972 [1992]: 548).

Introduction

One of the more significant developments over the past 25 years has been the emergence and widespread deployment of information and communication technology. The so-called 'digital revolution' has transformed our ordinary lives and perhaps had its most pervasive influence on work and organisation. These new technologies have been 'made at home' in the workplace and have had an important impact upon the ways in which we work and how we work with others. Healthcare is no exception. Medical organisation, professional practice, and our participation as patients has been subject to sustained change over the past couple of decades in part driven by the contribution and demands of the computer. Digital technologies have transformed, for example, medical records and institutional data, diagnosis and diagnostic categories, access to healthcare and the very consultation itself. They have an extraordinary impact on accounts and accountability, on the allocation and organisation of material and human resources and on professional and inter-professional practice. This is just the beginning. In July 2002 the British Government proudly announced an additional five billion pounds for new technology in the NHS, claiming it would radically transform the delivery of healthcare. One wag, the editor of a leading computing journal, commented that 'it would be rather like trying to build a bridge across the Atlantic'.

The sociology of health and illness, indeed sociology in general, has been a little reticent in exploring the ways in which information and communication technologies feature in everyday practice in work and organisations. Of course there has been substantial comment and debate about the information society and the like, but how these tools and technologies are encompassed and embodied within practical social action and interaction remains a little neglected. Over some years, *Sociology of Health and Illness* has published a number of significant papers which do indeed examine the ways in which new technologies, ranging from information systems and data bases through to inhalers, from X-ray imaging through to respiratory support systems, have been institutionalised within healthcare and gained sense and significance within practice. These papers raise a range of important issues concerning the ways in which technical tools are shaped with regard to practical circumstances in which they are used, and point to our relative

disregard for the ways in which these artefacts are used and entailed in practice within everyday healthcare. Drawing on a selective corpus of research published in the Journal over some years and recent developments within social and computer sciences we wish to delineate one or two issues and substantive concerns which might deserve further analytic attention in the coming decades.

In this paper, we adopt a rather narrow, a lay, conception of technology. We are particularly interested in exploring the ways in which tools and artefacts, in particular digital technologies, information and communication systems, feature in clinical practice healthcare. We begin by discussing a number of papers published in the Journal over the past couple of decades and explore the ways in which they contribute to our understanding of technology in the delivery of healthcare, and demarcate a range of substantive concerns and analytic issues. We then consider a burgeoning body of empirical research, naturalistic studies of work, interaction and organisations, which is having an important bearing on our understanding of new technology and the ways in which these artefacts are used within practice. Finally, we briefly discuss a couple of areas in which new technologies are having a profound impact on the delivery of healthcare and suggest ways in which they provide a vehicle for exploring how these tools and artefacts come to exist in practice. Underlying these different sections is a concern with directing attention to technology in practice and ways in which it can and might be subject to empirical inquiry.

Shaping technologies

The papers published in the Journal over the past 25 years concerned with technology reveal a diverse range of methodological and theoretical standpoints. Whilst predominantly 'qualitative' and relying upon ethnographic observation coupled with in-depth interviewing, the papers reflect a range of analytic developments we have witnessed more generally within sociology and social sciences over the past few decades. Despite their analytic diversity, the papers reflect a number of generic themes and issues; themes and issues which are concerned with prioritising the 'social' and demonstrating the ways in which technologies, ranging from information systems through to advanced resuscitation technologies, from imaging systems through to respiratory support tools, gain sense and significance within everyday activities and ordinary experience. In a sense, many of the papers are concerned with the 'social shaping of technology' and the ways in which systems, tools and artefacts come to feature, reflexively, through the emergence of communities of socially organised practice and reasoning. In part, the papers are concerned with charting the 'institutionalisation' of technology and how it comes to feature in peoples' everyday practical experience (Locker and Kaufert 1988, Pasveer 1989, Prout 1996 and Timmermans 1998).

Consider, for example, the paper by Locker and Kaufert (1988). It presents a detailed analysis of the impact of respiratory support technology on the quality of life and examines the ways in which this technology is progressively encompassed with the careers of those suffering post-respiratory disability. The study powerfully shows how the technologies can only be understood with regard to the conduct and practical experience of those using the tools to manage their breathing in ordinary day-to-day circumstances; the technology gaining its sense and determination through the ways in which it comes to feature in their everyday lives. The paper reveals the experiential tensions which emerge for the patients themselves, and explores the ways in which they attempt to reconcile different solutions for, and constraints of, managing breathing. In particular, the paper addresses how patients attempt to balance particular technical constraints with the quest for freedom and independence.

In a more historical vein, Pasveer (1989) explores how new tools and technologies depend upon the emergence of a body of socially organised practice and convention to enable particular occupations to deploy the systems within work and organisational life. Pasveer takes the case of X-ray imaging and argues that the technology has to be considered with regard to current patterns of knowledge and practice, rather than its immediate, unambiguous impact on established practices of medicine. In contrast to the idea that X-ray images immediately provided 'a new, visual way of rendering the world', the author powerfully shows that the images became progressively significant, their use and diagnostic significance evolving over some time. What could be argued to be 'inside' the images from the beginning, ready to be assimilated by radiology and the physicians, actually had to be shaped by the X-ray workers within the present medical context. Pasveer reveals that it was not until after the slow process of changing the form and content of the X-ray images, that routines and practices began to develop in order to transform into a compatible body of resource for those who would appreciate the use and meaning of the images in practice.

In an insightful study of advanced resuscitation technology, Timmermans (1998) draws on related analytic developments in organisational studies (*i.e.* Strauss *et al.* 1985 and Hughes 1958) and social studies of science and technology (*i.e.* Latour 1987), to examine how the technology is enveloped in practice and practical circumstance. He argues that the 'potential and power of a technological device to shape an interaction is not pre-given but is realised in practice'. Timmermans describes the ways in which patients, relatives, staff and healthcare providers seldom have the opportunity to express wishes and cope with the stressful difficulties of sudden death. The routine organisational arrangement forces the members of resuscitation teams to 'go through the motion' even though chances of revival are minimal or that relatives have expressed the wish for the patient to die at home. Timmermans explores these personal, practical and organisational circumstances to reveal the ways in which advanced resuscitation technologies, far from dehumanising

death, help provide meaning to the process of dying. Within a framework of legal constraint and resuscitation protocol, the technological environment and its procedures allow staff to make the process of sudden death more humane for relatives and families.

Also drawing on analytic issues and debates within the sociology of science and technology, Prout (1996) questions our ability to develop 'appropriate' accounts of medical technology, drawing on more traditional methodological standpoints within the social sciences. He argues that actor-network theory provides the analytic resources for re-specifying the relationship between the object and the subject, and technology and action. Taking the example of the metered dose inhaler, he reveals the ways in which technological devices and humans are being 'calibrated' and mutually constituted in hybrid networks. The paper addresses an issue that underlies many of the articles published in the Journal concerned with technology; how can we re-conceptualise the relationship between technology and practice whilst avoiding a technological or social determinism? Whilst developing a distinctive, and perhaps more radical 'solution' Prout (1996) delineates ways in which we can chart a course between the relativism of social constructionism, and the materialism which is sometimes thought to underlie many approaches to technology and the object in the social sciences (for related discussions see, for example, Woolgar 1988, Mackenzie 1996 and Button 1993).

A number of the papers in the Journal therefore explore the ways in which we can begin to re-specify the technology and practice and, in various ways, address how practical circumstances, procedure convention, culture, and the socio-political environment shape, even create, the sense and significance of systems and artefacts. The programmatic commitments of these papers reflect analytic developments which have largely emerged outside the sociology of health and illness and yet they reveal how technology in medicine furnishes a rich, though relatively unexplored, domain for empirical and conceptual enquiry. A number of the papers concerned with the social shaping of technology touch an area which pervades the sociology of health and illness, namely professional practice and the ways in which the delivery of healthcare is accomplished within particular organisational circumstances which bear upon the diagnosis and management of illness.

Technology and professional practice

In this regard, it is interesting to consider professional medical practice and the ways in which tools and technologies have come to feature in and transform the day-to-day work of personnel within healthcare. A number of papers in the Journal have addressed how technological developments have been embodied within practice and professional and inter-professional relations. For example, in his comparative analysis of the utilisation of a computer system in two separate renal units, Dent (1990) examines how different

organisational arrangements and circumstances affect the attitude and use of particular technologies. The particular system was designed to facilitate monitoring of patient data and to support medical audit and research. The two renal units responded very differently to the introduction of the technology. In one, where there was a strong commitment to education and research, there was positive reaction to the system amongst the consultants and yet some resistance from the nursing staff who found little practical benefit in a technology which demanded that work be restructured. In contrast, in the second Unit, nursing staff welcomed the system and used it for intensive data processing work; ironically, this led to the consultants becoming increasingly hostile to the technology. Dent shows how the use of the system and the responses to technological innovation are profoundly influenced by the work arrangements instantiated by the 'medical rationales' of the consultants and the organisational context found within the actual units.

Dent's study demonstrates how organisational arrangements and the boundaries between professional work and jurisdiction have a profound influence on the use and exploitation of technology. In the case of the renal computer system, relations between the nurses and the consultants play an important part in the utilisation and appreciation of the system. Tjora (2000) also addresses how the inter-professional relationship between the nurse and doctor bears upon the implementation and exploitation of new technologies. To elucidate some of these issues, Tjora discusses how call centres are having a profound impact on the position and practice of nurses. He argues that the systems in these centres have provided the opportunity for the nurses to exercise more autonomy in medical decision-making. In more conventional medical settings where nurses have similar forms of autonomy they are able to maintain, on a daily basis in the physical presence of the doctors, the traditional division of labour and scope of authority. In the emergency centres where these 'normal' encounters with the doctor are not immediately available, Tjora points to the possible role of communication technologies such as telephones, radio and advanced tracking systems as mediating the negotiation of the nurses' autonomy and resources for maintaining the inter-professional relations. In these emergency centres, as in other organisational settings in medicine (Dent 1990 and Pope 1991), Tjora shows that these new computer systems do not necessarily respect or preserve the procedures used in more traditional forms of practice. The medical index, designed by doctors as a guideline for the nurses screening tasks and provisional diagnostic work, did not reflect the collaborative nature of decision-making and the nurses personal competence and expertise. The medical indexes supported a more formal and individual approach to medical decision-making. Similarly, in her study of hospital waiting lists, Pope (1991) demonstrates how the introduction of computer-based systems failed to respect the conventional procedures used by healthcare professionals themselves and reveals the tension between administrative or

bureaucratic requirements (and associated performance criteria) and ordinary everyday demands and practices for managing patients.

In different ways therefore, these papers powerfully demonstrate how computer-based information systems and complex forms of equipment are not simply integrated into current practice and ways of working, but have a profound impact on the organisational arrangements, professional work and medical practice. The emergent and mutual constituting relationship between technology and practice is a pervasive theme, a theme which reveals how tools and artefacts come to feature in determinate, but unpredictable, ways in the organisation and delivery of healthcare.

Preserving identities

A long-standing and prevailing issue within the sociology of health and illness, from its outset in the writings of Henderson (1935) and Parsons (1951), derives from the tension between the formal application of specialist medical knowledge and the practical, contingent and organisational circumstances in which healthcare is delivered and received. In part, research on such varied topics as 'illness behaviour', the 'sick role' and 'medical communication' addresses this issue and examines the ways in which the experience of illness and the management of the sick is figured, transformed and ameliorated in practice. A number of papers in the Journal examine the potential of technologies to depersonalise medicine and are concerned with showing how 'communication and emotional work' (see Hochschild 1983) may counter the potentially alienating characteristics of tools and artefacts. As mentioned earlier, Timmermans (1998) provides an example of how a particular technology, which might appear dehumanising, is used by staff to ease the stress and burden of death for relatives and family. In his paper, Dent (1990) argues that the dominating explanation for the very different responses to the renal computer system emerge in the light of the opportunity for and ability of nurses to undertake data collection alongside the importance of emotional work in dialysis and training.

It is in papers by Strauss *et al.* (1982, 1985) however that the contribution of emotional labour and 'sentimental work' is explicitly addressed. Arguing that medical equipment and advanced technologies make an important contribution to patients' experience of medical encounters, Strauss and his colleagues explore 'the work that people do with, on and around medical equipment' (1985: 255). They classify sentimental work into a number of different types including trust, composure and identity work, and reveal how nurses and physicians provide comfort and meaning to medical situations and, in many cases, help avoid the potentially alienating impact of tools and technologies. Strauss *et al.* (1985) highlight the contemporary problem of technology contributing to depersonalisation and patients' feelings of 'being worked on'. One of the more frequent 'problems' identified in this emotional work is the

support in maintaining the patients' composure and identity, in situations in which machines and technologies significantly expose patients to clinical dangers and uncertain outcomes; expressions of discomfort and physical responses to the medical treatment that may disrupt the performance of the task or the procedure.

Conflicts of interest and perspectives can also emerge between the team members in various healthcare situations as an issue about patient care and the accomplishment of collaborative work. In the example of the surgical operation Fox (1994) argues that the distinct clinical separation between the anaesthetist and the surgeon – the two rival perspectives on the patient – engenders a 'surgical discourse' in which their identities and perspectives are constantly being challenged while negotiating the necessary collaboration. In this paper Fox mentions briefly, but explicitly, that technology contributes to the claims of authority and responsibilities in the negotiation of physical arrangements and inhabitation of space in the operating theatre. The 'machinery' of the anaesthetic machine is not normally understandable by the surgeon. Similar to the surgeon's area of competence defined by the art and complexity of the surgical procedures, the anaesthetists dominate the interpretations of the monitor readings for the benefit of the surgeon. Though it is not the main thesis of Fox's argument, the setting of an operating theatre opens up an important arena for the study of technology and its impact on clinical practice, inter-professional collaboration and patient care.

The relationship between technology and personal and professional identity, therefore, is a pervasive theme in many of the papers concerned with technology published in the Journal over the past couple of decades. It reflects the predominant analytic orientations of the Journal and more generally, the long-standing commitment within the social and political sciences to the idea that technologies depersonalise human conduct, practice and experience. In different ways however the papers published in the Journal attempt to counter this simplistic view of technology and explore the ways in which tools and technologies are progressively shaped by and integrated into the everyday activities of patients and practitioners. The papers focus on the deployment and diffusion of tools and technologies, and discuss how they gain significance and relevance within the practical and organisational circumstances of healthcare.

Despite the relatively few papers concerned with technology published in the Journal over the past 25 years we find a rich and varied assortment of insights and ideas, important empirical and conceptual contributions to our understanding of systems and artefacts in medicine. The papers illustrate ways in which tool and technologies come to feature in lay and professional experience and demonstrate the importance of taking artefacts seriously when addressing the social organisation of healthcare. The papers set the scene for sociological enquiry, and identify a number of analytic and empirical issues.

Each of the papers points to the importance of placing the practical circumstances, the situation in which tools and technologies are deployed, at the forefront of analytic agenda. They richly reveal how practical circumstances and context in healthcare bear upon the ways in which these tools and technologies come to be perceived and understood. They demonstrate how the character of these material artefacts is determined by participants themselves within the practicalities of their ordinary lives and as Sacks ([1972] 1992) once suggested, show how tools and technologies are 'made at home' within the daily activities of personnel and patients. The papers also examine how a socially-organised body of procedure and meaning(s), a local culture if you like, emerges enabling participants to use the particular tool or technology in circumstantially relevant ways, and to accomplish activities in co-operation with others be they colleagues or patients. Embedded, shared ways of seeing and understanding, of defining, if not constituting, the sense and significance of the tool or technology, pervades the characterisation of how these artefacts come to be made at home within the practical circumstances in which they are deployed and used. Moreover, the papers address how frames of reference, bodies of meaning(s) and convention, which pervade the deployment and use of these tools and technologies in healthcare, are seen to emerge at least in part through social interaction, whether between colleagues, as in the case of radiology teams, or between clinicians and patients. Most powerfully, these papers direct our attention towards the ways in which particular tools and technologies come to life, gain their determinate character, in and through the practical activities of the participants themselves, practical activities which are both sensitive to and reflexively constitute the organisational circumstances in which they arise.

In directing analytic attention towards the circumstances in which tools and technologies are deployed, the papers point to the analytic importance of the practical, indigenous use of the artefacts in everyday circumstances. Surprisingly, however, few of the papers are concerned with exploring the ways in which the particular tool or technology is used within the practical activities of the participants themselves, whether patients or clinicians. The various technologies themselves, their practical application and use, remains relatively unexplicated and one gains some sense of, but little detail, of the ways in which these tools figure in practical action. More importantly, perhaps, the pervasive concern with meaning and understanding and the ways in which technologies are embodied within practical circumstances, by virtue of the participants' emergent frames of reference and perceptual schema, turns attention away from the indigenous, socially-organised practices through which the particular tool or technology is used within specific actions and activities. The papers powerfully reveal the sociological importance of the local, the practical and the circumstantial, but the practised and routine deployment of the artefact within specific courses of action, and interaction remains largely unexamined.

The analytic concern that underlies a number of the papers in revealing the shared body of convention and experience which situationally enables the particular technology, draws attention away from the emergent and the contingent; indeed the very elements which are central to some of the programmatic statements. The ways in which a particular tool or artefact is used and understood with regard to the practicalities at hand, the circumstances here and now, and the contingencies which have arisen, remain disregarded, and in consequence we lose sight of the technology and the practices through which it features in practical action. Perhaps the most pervasive circumstantial feature of these tools and technologies in healthcare, and any other domain for that matter, are the ways in which their use is dependent upon, mediated through, and shaped with regard to social interaction; that is, the dealings between personnel and patients within healthcare. Circumstances and contingencies emerge regarding the actions and activities of others. The use of the artefact, at some here-and-now, is dependent upon and embedded in the practical interactional circumstances in which it is deployed. The papers demonstrate the significance of interaction to the practical use and experience of the particular tool and technology, and yet interaction remains largely unexplicated in the analysis. They reveal the importance of social interaction to understanding how tools and technologies are used within everyday practical circumstances, yet how these objects and artefacts feature in conduct and interaction remains somewhat neglected.

Workplace studies: technologies in practice

There is a growing corpus of research in the social sciences concerned with technology in action and the ways in which tools and artefacts feature in conduct and interaction in organisational environments. This corpus of research has come to be known as ‘workplace studies’. It includes studies of air traffic control, emergency dispatch centres, control rooms, news rooms, law firms, hospitals and primary healthcare (see for example Button and Sharrock 1997, Goodwin and Goodwin 1996, Harper 1998, Hughes *et al.* 1992, Randall and Hughes 1995, Suchman 1993, Whalen 1995, and Heath and Luff 1996 and 2000 and Luff *et al.* 2000). These studies address the social and interactional organisation of workplace activities and the ways in which tools and technologies, ranging from paper documents through to complex multimedia systems, feature in day-to-day work and collaboration. They examine the ways in which artefacts are ‘made at home’ in the workplace and demonstrate how the use of even the most seemingly ‘personal’ computer rests upon a complex social organisation; an indigenous, tacit body of practice and reasoning through which the tools and technologies gain their occasioned sense and relevance from within action and interaction. These studies with their interest in the social and interactional character of organisational activities, represent perhaps a reflowering of the sociology of work, unparalleled save

perhaps by the pioneering initiatives of E. C. Hughes (1958) and his colleagues in Chicago following the Second World War. As yet however, this burgeoning body of empirical research remains relatively unknown within the sociology of health and illness and its empirical and conceptual contribution underdeveloped within the delivery and experience of healthcare.

Workplace studies have curious provenance. They have emerged in the light of a number of theoretical debates, empirical shortcomings, methodological inconsistencies, technological innovations and practical problems. For example, over the past decade or so, conventional models of human conduct and reasoning within Human Computer Interaction (HCI) and cognitive science have been subject to sustained criticism (Dreyfus 1972, Winograd and Flores 1986 and Searle 1985). In her influential monograph, Suchman (1987) demonstrates the shortcomings of plan-based, goal-oriented, cognitive models of technology use, and their disregard of the context of conduct, the contingent, and, most fundamentally, the socially-organised competencies which underpin artefacts in action. She reveals the ways in which these models misconceive the user and mischaracterise tasks and activities and show how they have led to a disregard for the ways in which people, in ordinary, everyday circumstances, use tools and technologies, objects and artefacts, to accomplish social action and interaction. These conceptual and empirical shortcomings were not however addressed, at least a decade or so ago, by corresponding research in the social sciences. Indeed, sociology, for very different programmatic and substantive reasons, remained largely uninterested in the artefact in practical action.

The relative absence of empirical studies of technology in use, coupled with sustained criticism of the programmatic commitments in HCI and cognitive science, were given a significance, by virtue of an important practical problem. There was, and is, a growing recognition that tools and technologies, including highly-sophisticated computer systems, frequently fail when deployed in organisations (e.g. Standish 1995). Indeed, over the past decade or so we have witnessed a series of high-profile disasters in areas as diverse as financial services, transportation and healthcare. For example, consider the eight years and estimated sums of between £30m and £50 million which were wasted on attempting to develop an integrated computer system for Wessex Regional Health Authority in the United Kingdom; a problem largely attributed to the failure to determine a clear set of requirements from the various medical and administrative disciplines involved (Collins and Bicknell 1997). Or consider the tragic overdoses that arose from the use of the computer-supported Therac-25 Radiation Therapy System; a problem that attributed the difficulties to using the interface in practice (Neumann 1995). Or recall the disaster that arose from the introduction of the London Ambulance Service's Computer Aided Dispatch System; a disaster that the official report attributed to the failure to understand the practicalities and constraints of the dispatchers' work (Page *et al.* 1993). These and a host of other technological failures, raised severe questions about the ability of

technology and its developers to support, let alone enhance, workplace activities. They led to a growing recognition that we know little about the ways in which people use mundane artefacts in ordinary situations, let alone complex computer systems. It also pointed to the importance of understanding the setting and indigenous practice before developing and deploying a computer system. These failures, and the seemingly less important problems which often arise with the deployment of new technology, once again revealed the shortcomings of the individualistic and cognitive models which underlie HCI and related applied disciplines such as ergonomics and requirements engineering. These programmatic debates, therefore, coalesce with a range of practical problems to facilitate the development of a body of empirical research which took indigenous, situated practical action seriously and in particular the ways in which people use tools and technologies within ordinary circumstances to accomplish and co-ordinate social actions and activities. The individualistic, cognitive and experimental is replaced by the interactional, social and naturalistic.

There are a small but growing number of workplace studies concerned with tools and technologies in healthcare. These studies are, however, primarily concerned with exploring the ways in which ethnographic research can inform thinking about the design and deployment of new technologies. They do, however, raise a number of important issues with regard to the ways in which we might consider the practical and indigenous use of artefacts in action. So, for example, in their studies concerned with the 'digital hospital', Tellioglu and Wagner (2001) examine how existing resources – documents, images, displays and the like – enable personnel to co-ordinate a complex array of activities distributed within different spaces and locales. In a different vein, Krasti (2001) examines the indigenous practices associated with the use of materials such as timesheets, radiological images and medical records, and considers their implications for the development of more situationally-relevant technical support. Hartswood and Proctor (2000) explore the ways in which radiologists draw upon various material resources, including paperwork, that are utilised in the collaborative management of the problems that arise when they are analysing mammograms. In a different fashion, Bossen (2002) considers how a range of heterogeneous artefacts – including different kinds of whiteboards, work schedules, notes and examination sheets – are used alongside each other, interwoven, for various purposes in a range of locations through the wards and offices of a hospital. In different ways, these studies reveal the interdependence of material resources and the ways in which a variety of tools and artefacts are brought to bear in the accomplishment of particular actions and activities. They also point to the ways in which objects and artefacts come to mediate inter-professional collaboration and the dealings between patients and personnel. More importantly perhaps, they reveal the ways in which the character of the artefacts and the practices through which they are used and deployed emerge in and through social interaction.

Despite the widespread deployment of new technologies in medicine and the growing commitment to transforming the delivery of healthcare through information and communication systems, there still remains, however, relatively little research concerned with the ways in which material resources and artefacts feature in the day-to-day delivery of healthcare. It is perhaps worthwhile considering two or three areas in which technology is having an increasing impact on the delivery and experience of healthcare, and briefly to explore how they might be subject to further scrutiny in the light of one or two workplace studies. We believe that these areas deserve further consideration and are fields that provide important analytic opportunities for the types of empirical study for which the Journal is well known.

Information systems and medical work

As Weber pointed out in his theory of bureaucracy, files and documents are an essential part of the modern organisation, in both the private and public sectors: the 'advanced institutions of capitalism'. The modern medical organisation is no exception. Substantial financial and human resources are devoted to documenting information concerning the activities of organisational personnel, especially in their dealings with the general public and, in particular, patients. There is a long-standing interest in the sociology of health and illness, reflected in a number of papers published in the Journal, concerned with the medical record, and the ways in which it features within everyday clinical practice (see, for example, Rees 1981, Raffel 1979, Heath 1982). In part, driven by Garfinkel's (with Bittner) (1967) pioneering paper on clinical records, we saw the emergence of a range of studies that examine the record in action and indigenous practice and reasoning that informs their production and intelligibility. In the last two decades, computing technology has had a wide-ranging impact upon the collection, analysis and dissemination of information in medicine and has provided the resources through which new forms of accountability and measurement have evolved. Surprisingly, perhaps, save for one or two exceptions (for example Berg 1997a, 1997b, Greatbatch *et al.* 1993), this tradition of research has not been pursued in the past decade or so, despite the pervasive deployment of computer systems in both primary and secondary healthcare to replace paper notes with the electronic record.

For example, over the last decade or so we have witnessed the widespread deployment of information technology into primary healthcare. The principal aim of the system(s) would be to provide a computerised patient record for general practitioners which would offer significant advantages over the paper notes. It would allow information to be more formally documented and retrieved with regard to a range of potentially relevant categories. It would also enable prescriptions and the like to be printed directly from the record. Moreover, associated databases would allow practitioners easy access to information regarding treatment programmes and the like. It was envisaged

that within a few years the computerised system would largely replace the paper record. However, despite substantial investment and successive changes and improvements to the software, many general practitioners continue to update and use the paper record alongside the computer-based system.

In general practice, as in other areas of medicine, doctors rely upon a body of socially-organised, yet tacit, practices through which they selectively document information in the record and make sense of the materials written by others. The community of practices which is evolving with and through the use of these different information 'systems', however, cannot be dissociated from the consultation and, in particular, the interaction between patient and doctor. Perhaps more than any other field of medical work, information systems in general practice are primarily used, and are a critical resource in, the consultation itself. Information is documented, retrieved and used within the interaction with the patient, and the various tools and artefacts, be they keyboards and monitors or pens and paper, gain their relevance by virtue of their use then and there in dealing with the patient. For instance, doctors routinely retrieve and glance at the last entry in the patient's record prior to beginning the consultation, thereby tailoring topic initiation to the potential reason for the visit, or, on hearing a symptom, doctors enter information into the system, momentarily delaying their next question until the completion of the entry. The patient's agreement with, or at least alignment to, assessment and recommended treatment, occasions a series of actions through which doctors enter information into various sub-fields and, in many cases, print a prescription. Patients are highly sensitive to the doctor's use of the system, and doctors to the patient's orientation to the use of the system, delaying for example the gist of a description or request until the doctor completes a series of key strokes, or glances back at the patient. The use of the system evolves moment by moment within the developing course of the interaction between patient and doctor, just as the 'requirements and demands' of the system are recognised and invoked from within that interaction (see for example Greatbatch *et al.* 1993, Heath and Luff 2000). The technology, its sense and significance, is constituted by the participants themselves, both patient and doctor, within the emerging course of the interaction. In disregarding the interactional circumstances in which it is deployed and used, we ignore the ways in which these simple tools and artefacts feature within the practicalities and delivery of healthcare. The introduction of basic computer information systems has had a profound impact on the character and organisation of the consultation. It has transformed the ways in which doctors gather and retrieve information, and has infused the production and co-ordination of action between patient and practitioner. It is within the practicalities of the consultation that these technologies operate, and it is through a body of socially-organised practice that doctors are able to use the systems in their interaction with patients. The deployment of the technology has had a profound impact on the paper record and its ability to serve a range of clinical applications. Whilst some

practitioners continue to record information in the paper notes, and occasionally read the cards, the material has to be routinely read in conjunction with details within the corresponding electronic record; they no longer stand alone nor serve the practical consultative purposes that they once underpinned. The co-production and intelligibility of the paper and electronic record remains underexplored, as do ways in which practitioners use various bits and pieces of seemingly scrap paper to document information which, in some cases, will be entered more formally into the electronic record. These records and the ways in which they are assembled, read and used, cannot be dissociated from the interaction between patient and doctor within the consultation itself and the contingencies and concerns which arise therein. Given the long-standing interest in interpersonal communication in healthcare, (see for example Byrne and Long 1976, Strong 1979, West 1985, Heath 1986, Peräkylä 1995, Silverman 1997, Heritage and Maynard forthcoming) the field is well-placed to examine the ways in which material resources, tools and technologies feature in the social interactional accomplishment of clinical activities. Such research might not only complement the growing body of fine-grained empirical studies of the organisation of talk and interaction in medicine, but contribute to our understanding of the ways in which professional practice relies upon, and is constituted through, material artefacts such as medical records, pieces of paper and complex information systems.

Call centres and technology-mediated services

New technologies are increasingly providing the resources for reorganising the delivery of services both in the private and public sectors. Healthcare is no exception. Conventional information systems coupled with the telephone have led to the development of new on-line services through the ubiquitous call centre and the Internet. Over the last few years, for example, in the United Kingdom substantial public funding has been invested in the development of NHDirect and NHSOnline, and it is widely acknowledged that these new services have met with significant public demand. These services are having a profound impact not only on the ways in which the public engage the formal healthcare system, but on inter-professional co-operation and collaboration. There is a growing body of research which is concerned with the organisation of work in, and management of, call centres, but, save for one or two exceptions, as yet there are few sociological studies of the ways in which health services are delivered either over the phone or on-line (see for example Hanlon 2002).

In other related settings however, the social and interactional organisation of new services delivered through call centres has been the subject of detailed inquiry. Researchers, particularly Whalen and Zimmerman (1987), Whalen, Zimmerman and Whalen (1988) and Whalen (1995), have, through extensive field observation and detailed analysis of calls, revealed how the

use of the technology for call taking both shapes the conduct of the participants and can be shaped by the ongoing interaction. Despite computer systems for call-takers seemingly specifying the actual questions and the order in which they should be asked, the use of the technologies and the interaction are tightly interwoven. On occasions the ordering of the interaction, engendered through the technology, may become problematic, requiring explicit talk or even repair. Or the use of the technology may be transformed to suit interactional purposes, call-takers developing ways of utilising categories available in the system (such as the ubiquitous 'other') or ways of ignoring system queries, in order to avoid problematic topics or asking the caller irrelevant questions. Different types of interface and designs of systems support such practices to different extents, and demonstrate how easily such shifts between items can be handled on the screen and in the interaction with the caller. With regard to this, practices can emerge through which call-takers (and indirectly callers) shape their interaction in order to make the technology at 'home in the world'. As in the case of information systems for medical-record-keeping, the detailed study of the introduction of a technology makes apparent some of the resources through which the activity it is meant to support is accomplished. Indeed, in these and other studies of other emergency services in the UK, Europe and the United States, it becomes apparent how assessments of the location of patients, their conditions and circumstances are practical and skilful achievements. Such assessments are accomplished remotely, despite the participants having asymmetric access to resources that would appear critical for the activity. As well as what could be called a community of practice, the participants draw upon resources made apparent through the interaction with the other on the telephone line. Both participants relying on the appropriate and reasonable contributions to be made by the other. What may appear to be standardised routine activities undertaken by 'judgmental dopes' may indeed be highly complex practices produced through the interweaving of different medical and organisational resources produced in collaboration with others.

As further healthcare services are offered both through the telephone or the Internet, it would seem critical to understand how these services are being delivered as practical accomplishments by the participants. It would seem also important not to overlook cases where healthcare professionals have long-standing skills in accomplishing technologically-mediated work, an understanding of which is still a challenge for social scientific study.

Operating theatres

As in other medical domains, operating theatres, and other critical settings such as intensive care units and emergency rooms, have been subject to considerable technological and organisational developments. New sophisticated treatments are often accompanied by related developments in computational and related

technologies. For example, one of the more significant technological developments is the introduction of new ways of visualising and augmenting surgical procedures. It has been recognised that these new developments have influenced and to some extent changed the traditional ways in which the members of the surgical team made up of various disciplines, engage in the performance of specialist tasks, communicate and co-ordinate their activities. Despite the long-standing interest in professional knowledge, inter-occupational work and interpersonal communication in the sociology of health and illness over the last few decades, very little research has been directed towards these issues with respect to the operating theatre, save the important exceptions of Fox (1994) and more recently Pope (2002) and Hindmarsh and Pilnick (2002).

Recent developments in operating theatres make these settings particularly challenging domains for analysis. Recent technologies in use within surgery involve innovations such as computer-assisted systems for image-guided surgery and intelligent warning systems for the monitoring of patient conditions and machine failures. These technological developments appear to have improved the quality and safety of healthcare. However, it remains unexplored whether and how these new advanced technologies facilitate the interaction and collaboration within the surgical team. In particular, it is as yet unclear how highly complex technologies feature in the co-ordination of activities and the ways in which patients are sustained through complex and highly contingent forms of communication and collaboration among practitioners with different concerns and responsibilities.

Researchers concerned with the use of technologies in complex settings have examined how features of images and displays are made apparent to others in interaction (*e.g.* Goodwin and Goodwin 1996). In the surgical domain, Nardi *et al.* (1995) reveal the ways that video monitors, displaying images of the intra-operative procedures in neurosurgery, provide other members of the team with 'remote access' to the field of the surgery. Such resources provide nurses, for example, with a sense of a domain to which they have no direct access, and with a sense of the emerging course of action being undertaken in the surgery. These allow them to undertake relevant actions prospectively, with little need for explicit instructions or interpersonal communication, for example to prepare the next relevant instrument to be handed over to the surgeon. In a related domain, Mondada (2001) explores how video cameras are used within 'keyhole' surgical procedures not only as resources for local participants within the operating theatre, but also to audiences or professionals who may be some distance away, even on a different continent. She reveals how the talk of the surgeon can be co-ordinated with the image presented through the technology, and is shaped with respect to the local demands of surgery and the surgical team as well as for didactic purposes to students and other experts.

The interactional practices through which surgical teams accomplish a number of interrelated collaborative activities are also apparent with regard to other more common surgical technologies, for examples, alarm monitoring

systems. One might assume, for instance, that an alarm is an unambiguous warning of a particular event or problem which sets in motion a given procedure to deal with the matter indicated by the alarm. In many complex work situations, given alarms are in the first instance the responsibility of a particular participant, and can be ignored by others, unless the matter is dealt with relatively rapidly. So, for example, an anaesthetist or an anaesthetic team would have responsibility for monitoring and handling the alarms associated with the systems monitoring the patient's respiratory systems. However, in many cases particular alarms, or cases where alarms occur, are relevant to others in the operating theatre. From some pilot studies we have been recently undertaking it is apparent that alarms are a frequent, almost omnipresent, feature in an operating theatre. Anaesthetists then have to assess the alarm and when relevant make it apparent that this is consequential to others, for example the principal surgeon. It may be, and in many cases it may be critical, that in making surgeons aware of the importance of the alarm, surgeons do not abandon their ongoing surgical activities, as might be engendered by an explicit utterance or a direct glance. Hence, anaesthetists may simply highlight the significance of an alarm by exploiting a delicate look into the area of the surgeon's activity or by moving towards the surgeon and exposing a particular tool in the field of the surgeon's view. Rather than interrupting the activities, we notice how the participants in this way are able to experience the concerns and responsibilities of others. This may be through a sensitivity to the significance or insignificance of a particular alarm for another, or by a sensitivity to each others' views, manipulations, and examinations of tools and technologies in the immediate physical environment. It is interesting to observe that tools and technologies, such as in this example – are often designed and developed for the individual practitioner – and yet they provide important resources for the co-ordination of activities and the collaborative sensitivity to events and emerging problems.

By ignoring the intimate and reflexive relationship between technologies and actual organisational practice, and the ways in which technologies are used in interaction, we disregard the opportunities for developing an understanding of the ways in which technology features in everyday medical practice and, in particular, the detailed conduct and interaction of the participants themselves. It is in and through social interaction that technology in medicine gains its sense and significance and that tools and artefacts, be they complex monitoring equipment or paper documents, come to be used and articulated in routine practice and practical circumstances.

Summary

Sociology of Health and Illness provides an ideal forum in which to present, discuss and develop research on technology, health and illness. Over the past two decades or so it has become one of the leading venues for the publication

of naturalistic research on medical practice, healthcare and the experience of illness, and has powerfully reflected the analytic innovation and diversity of contemporary social science. It has published an important range of papers concerned with technology; papers which provide a framework of issues, ideas and conceptual distinctions through careful, naturalistic studies of tools and artefacts in an everyday setting. These papers have delineated the ways in which the analysis of tools and technologies bear upon many of the central concerns and topics of the sociology of health and illness, ranging from the experience of illness through to professional identity, from interpersonal communication to organisational change. These papers provide a starting point, raising a range of substantive and conceptual issues, which we believe should increasingly inform research in the sociology of health and illness in the coming years. The emergence of workplace studies and analytic developments in other disciplines, including, for example, distributed cognition and activity theory, provide their analytic and substantive resources further to develop research on technology in action, just as the Journal can provide a forum to attract new researchers from a variety of disciplines to the sociology of health and illness. Social, political and organisational developments over the coming years will place technology and technological change at the centre of healthcare and its delivery, and it is critical for the sociology of illness to take these developments seriously and place technology in action and interaction at the heart of the analytic agenda.

*Address for correspondence: Christian Heath, Work, Interaction and Technology Group, King's College London, Franklin Wilkins Building, London SE1 8WA
e-mail: Christian.Heath@kcl.ac.uk*

Acknowledgements

We would like to thank Hubert Knoblauch, Jon Hindmarsh, Dirk vom Lehn and David Greatbatch for their wide-ranging contributions to the discussion of many of the issues and materials addressed here. We are also very grateful to the editors and anonymous reviewers for their helpful comments on earlier drafts of this article.

References

- Berg, M. (1997a) 'On distribution, drift and the electronic medical record: Some tools for the sociology of the formal'. In *Proceedings of European Conference on Computer Supported Cooperative Work '97*, Lancaster.
- Berg, M. (1997b) *Rationalising Medical Work: Decision Support Techniques and Medical Practice*. Cambridge MA: MIT Press.
- Bossen, C. (2002) The parameters of common information spaces – the heterogeneity of cooperative work of a hospital ward. In *Proceedings of Computer Supported Cooperative Work 2002*, New Orleans, November 16–20.

- Button, G. (1993) The curious case of the disappearing technology. In Button, G. (eds) *Technology in Working Order*. London: Routledge.
- Button, G. and Sharrock, W. (1997) The production of order and the order of production, in *Proceedings of ECSEW '97*, Lancaster.
- Byrne, P. and Long, B. (1976) *Doctors Talking to Patients*. London: HMSO.
- Collins, T. and Bicknell, D. (1997) *Crash: Ten Easy Ways to Avoid Computer Disaster*. London: Simon and Schuster.
- Dent, M. (1990) Organisation and change in renal work: a study of the impact of a computer system within two hospitals, *Sociology of Health and Illness*, 12, 4, 413–31.
- Dreyfus, H. L. (1972) *What Computers Still Can't Do: a Critique of Artificial Reason*. 1st Edition. Cambridge, MA: MIT Press.
- Fox, N. (1994) Anaesthetist, the discourse on patient fitness and the organisation of surgery, *Sociology of Health and Illness*, 16, 1, 1–18.
- Garfinkel, H. with B. (1967) *Studies in Ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.
- Goodwin, C. and Goodwin, M. H. (1996) Seeing as a Situated Activity: Formulating Planes. In Engeström, Y. and Middleton, D. (eds) *Cognition and Communication at Work*. Cambridge: Cambridge University Press.
- Greatbatch, D., Luff, P., Heath, C. C. and Champion, P. (1993) Interpersonal communication and human-computer interaction: an examination of the use of computers in medical consultations, *Interacting With Computers*, 5, 2, 193–216.
- Hanlon, G. (2002) Tech, trust and expertise in a risk society – the case of NHS Direct. Paper Presented at Conference on Information for Patients and Public: the Role of ICTs. University of Brighton. October 2002.
- Harper, R. H. R. (1998) *Inside the IMF: an Ethnography of Documents, Technology and Organizational Action*. London: Academic Press.
- Hartswood, M. and Proctor, R. (2000) Design guidelines for dealing with breakdowns and repairs in collaborative work settings, *International Journal of Human-Computer Studies*, 53, 1, 91–120.
- Heath, C. C. (1986) *Body Movement and speech in Medical Interaction*. Cambridge: Cambridge University Press.
- Heath, C. C. (1982) Preserving the consultation: medical record cards and professional conduct, *Sociology of Health and Illness*, 4, 1, 56–74.
- Heath, C. C. and Luff, P. K. (1996) Convergent activities: collaborative work and multimedia technology in London Underground Line control rooms. In *Cognition and Communication at Work: Distributed Cognition in the Workplace* D. Middleton, and Y. Engestrom, (eds). Cambridge: Cambridge University Press.
- Heath, C. C. and Luff, P. K. (2000) *Technology in Action*. Cambridge: Cambridge University Press.
- Henderson, L. J. (1935) Physician and patient as a social system, *New England Journal of Medicine*, 212, 2, 819–23.
- Heritage, J. C. and Maynard, D. (forthcoming) *Practising Medicine: Talk and Action in Primary Care Encounters*. Cambridge: Cambridge University Press.
- Hindmarsh, J. and Pilnick, A. (2002) The tacit order of teamwork: collaboration and embodied conduct in anaesthesia, *The Sociological Quarterly*, 43, 2, 139–64.
- Hochschild, A. R. (1983) *The Managed Heart: Commercialisation of Human Feeling*. London: University of California Press.
- Hughes, E. C. (1958) *Men and their Work*. Glencoe: Free Press.

- Hughes, J. A., Randall, D. R. and Shapiro, D. (1992) Faltering from ethnography to design. In *Proceedings of CSCW '92*, Toronto, Canada, Oct 31 – Nov 4.
- Hughes, J., O'Brien, J., Rodden, T. and Rouncefield, M. (1997) 'Designing with ethnography: a presentation framework for design'. In *Proceedings of Symposium on Designing Interactive Systems (DIS '97)*, Amsterdam.
- Krasti, H. (2001) Bridging work practice and system design integrating systemic analysis, appreciative intervention and practitioner participation, *CSCW Journal*, 10, 2, 211–46.
- Latour, B. (1987) *Science in Action*. Milton Keynes: Open University Press.
- Locker, D. and Kaufert, J. (1988) The breath of life: medical technology and the careers of people with post-respiratory poliomyelitis, *Sociology of Health and Illness*, 10, 1, 23–40.
- Luff, P. K., Hindmarsh, J. and Heath, C. C. (2000) *Workplace Studies: Recovering Work Practice and Informing System Design*. Cambridge: Cambridge University Press.
- Mackenzie, D. (1996) *Knowing Machines: Essays on Technical Change*. Cambridge, MA: MIT Press.
- Mondada, L. (2001) Operating together through videoconferencing. In *Proceedings of Orders of Ordinary Action*, Manchester, 9–11 July.
- Nardi, B. A., Schwartz, H., Kuchinsky, A., Leichner, R., Whitaker, S. and Sclabassi, R. (1995) Turning away from talking heads: the use of video-as-data in neurosurgery. In Emmott, S. J. (ed) *Information Superhighways: Multimedia Users and Futures*. London and San Diego: Academic Press.
- Neumann, P. G. (1995) *Computer-Related Risks*. Reading MA: Addison Wesley.
- Page, D., Williams, P. and Boyd, D. (1993) *Report of the Inquiry into the London Ambulance Service*. The Communications Directorate, South West Thames Regional Health Authority.
- Parsons, A. S. (1951) *The Social System*. Glencoe: Free Press.
- Pasveer, B. (1989) Knowledge of shadows: the introduction of X-ray images in medicine, *Sociology of Health and Illness*, 11, 4, 360–81.
- Peräkylä, A. (1995) *Aids Counselling: Institutional Interaction and Clinical Practice*. Cambridge: Cambridge University Press.
- Pope, C. (1991) Trouble in store: some thoughts on the management of waiting lists, *Sociology of Health and Illness*, 13, 2, 193–212.
- Pope, C. (2002) Contingency in everyday surgical work, *Sociology of Health and Illness*, 24, 4, 369–84.
- Prout, A. (1996) Actor-network theory, technology and medical sociology: an illustrative analysis of the metered dose inhaler, *Sociology of Health and Illness*, 18, 2, 198–219.
- Raffel, S. (1979) *On Record and File*. London: Routledge and Kegan Paul.
- Randall, D. and Hughes, J. A. (1995) Sociology, CSCW and working with customers. In Thomas, P. (ed) *The Social and Interaction Dimensions of Human-Computer-Interfaces*. Cambridge: Cambridge University Press.
- Rees, C. (1981) Records and hospital routine. In Atkinson, P. and C. Heath (eds) *Medical Work: Realities and Routines*. Farnborough: Gower.
- Sacks, H. (1992) *Lectures in Conversation: Volume II (1968–72)*. Oxford: Blackwell.
- Searle, J. R. (1985) *Minds, Brains and Science*. Cambridge MA: Harvard University Press.
- Silverman, D. (1997) *Discourses of Counseling: HIV Counseling as Social Interaction*. London: Sage.

- Standish Group (1995) *The Chaos Report*. West Yarmouth, USA: The Standish Group International Inc.
- Strauss, A., Fagerhaugh, S., Suczek, B. and Wiener, C. (1982) Sentimental work in the technologized hospital, *Sociology of Health and Illness*, 4, 3, 254–78.
- Strauss, A. L., Fayerhaugh, S., Suczek, B. and Weiner, C. (1985) *The Social Organisation of Medical Work*. London: University of Chicago Press.
- Strong, P. (1979) *The Ceremonial Order of the Clinic*. London: Routledge.
- Suchman, L. (1987) *Plans and Situated Actions: the Problem of Human-Machine Communication*. Cambridge: Cambridge University Press.
- Suchman, L. (1993) Technologies of accountability: on lizards and aeroplanes. In Button, G. (ed) *Technology in Working Order*. London: Routledge.
- Tellioglu, H. and Wagner, I. (2001) Work practices surrounding PACS: the politics of space in hospitals, *CSCW Journal*, 10, 2, 163–88.
- the Public: The Role of ICTs', University of Brighton October 2002.
- Timmermans, S. (1998) Resuscitation technology in the emergency department: towards a dignified death, *Sociology of Health and Illness*, 20, 2, 144–67.
- Tjora, A. H. (2000) The technological mediation of the nursing-medical boundary, *Sociology of Health and Illness*, 22, 6, 721–41.
- West, C. (1984) *Routine Complications: Troubles in Talk between Doctors and Patients*. Bloomington IN: Indiana University Press.
- Whalen, J. (1995) A technology of order production: computer-aided dispatch in public safety communication. In ten Have, P. and Psathas, G. (eds) *Situated Order: Studies in the Social Organisation of Talk and Embodied Activities*. Washington: University Press of America.
- Whalen, J., Zimmerman, D. and Whalen, M. (1988) When works fail: a single case analysis, *Communication Yearbook*, 11, 406–32.
- Whalen, M. and Zimmerman, D. H. (1987) Sequential and institutional contexts in calls for help, *Social Psychology Quarterly*, 50, 172–85.
- Winograd, T. and Flores, F. (1986) *Understanding Computers and Cognition: a New Foundation for Design*. Norwood, NJ: Addison-Wesley.
- Woolgar, S. (1988) *Science: the very Idea*. Chichester: Ellis Horwood.