Accounting for knowledge embedded in physical objects and environments: The role of artefacts in transferring knowledge.

Abstract

The intention to investigate the role of artefacts (objects and environments) in codifying, embedding and disseminating knowledge was inspired by an awareness that organisations across all sectors are increasingly being asked not only to provide products in the first instance, but also to support them throughout their service life. Thus a move from product-delivery to product-service designs is suggested. This paper considers ways in which knowledge can be embedded into the physical properties of artefacts and how this can consequently aid the dissemination and management of knowledge in and across stages of life cycles. A literature review and fieldwork based on an ethnomethodological approach are used to investigate this topic. Accounts of the situated meaning of artefacts within social processes are obtained using ethnographic armchair research. Unique adequacy is used to achieve an understanding of how people make sense of artefacts. The initial findings of the current research show that knowledge can be embedded or encoded into the physical properties of artefacts and that this can be successfully transferred from artefact to user.

Key words: ethnomethodology; artefacts; unique adequacy; knowledge management; embedded

Introduction

The intention to investigate the role of artefacts (objects and environments) in codifying, embedding and disseminating knowledge has been inspired by the objectives of the Knowledge and Information Management (KIM) Grand Challenge Project. The project recognizes that, 'in response to customers' changing needs, organizations across all sectors are increasingly being asked not only to provide products in the first instance, but also to support them throughout their service life' (KIM 2006). Thus a move from product-delivery to product-service designs is suggested. KIM emphasizes the need to consider ways in which knowledge can be preserved in practices, records and artefacts, in order to support service throughout the life cycle of a product. The broad aim of this research is to investigate how knowledge can be preserved in artefacts and how this consequently aids its dissemination and management in and across stages of life cycles of products.

This paper looks at the role of artefacts within social practices and at how codified and embedded knowledge can be communicated from artefact to user. In the context of this paper codified knowledge refers to written knowledge or that which is encoded in signs, for example, a piece of paper bearing a programme of events or sign showing by way of an arrow whether one should turn left or right (Collins 1993). Embedded knowledge on the other hand refers to knowledge which is built into the physical properties of artefacts for the purpose of aiding the transfer of knowledge from artefact to user. An example of this is how people are able to tell the direction a door should open without the need to rely on written instructions or signs. However, it ought to be pointed out at this early stage that the use of the term ***embedded knowledge*** in this context is yet to be acknowledged. In generally the term is commonly used in the field of design to refer to knowledge which is linked with tools and practices, rather than explicitly codified or represented (Collins, 1993). For example, an information system may have knowledge embedded into its design. In knowledge management, a distinction is drawn between knowledge and information (Davenport and Prusak, 1998). There is a picture of codified information as artefact on the one hand and practice as knowledge on the other. In this paper the limitations of this approach are highlighted

with a view to suggesting a third concept that extends and complements it. The third concept is that of artefacts as bearers of knowledge or information. Thus, the role of objects and environments in codifying, embedding and disseminating knowledge within the context of social processes is explored.

This research which is in its early stages has partly achieved its aims through a review of literature and some fieldwork. The initial findings indicate that knowledge can be embedded in the physical properties of artefacts in such a way that communication is made explicit between artefact and user. An ethnomethodological approach is used to produce uniquely adequate (UA) accounts of the situated meaning of artefacts within social processes (Rooke and Kagioglou 2007). This approach primarily adopts auto-ethnographic (Hockey and Collinson, 2006) and 'armchair' research (Francis and Hester 2004) techniques. Other techniques include ethnographic interviews, participant observation, direct observation and the analysis of documents and photographs of artefacts..

The first part of the paper briefly looks at the meaning of key terms; knowledge and knowledge management. The second part is a research report which starts by highlighting the value of the physical properties of artefacts and ends with a look at empirical findings from the researcher's auto-ethnography research. An analysis of photographs of artefacts is offered in this section. The main parts of the paper are followed by the standard sections on research methodology, findings and discussions, conclusion and further research and acknowledgements.

What is knowledge?

Investigating the role played by artefacts in the codification, embedding and dissemination of knowledge within social processes cannot be achieved without first paying attention to the meaning of the key concepts: knowledge and knowledge management. As the move from product-delivery to product-service (KIM 2006) gains speed, the need to manage the flow of knowledge throughout the service life of a product cannot be ignored. This suggests a need, on the part of designers or manufacturers, to embed or encode in artefacts the kind of knowledge that will make its flow from artefact to user smooth. McInerney (2002), suggests that 'an understanding of knowledge itself is key to effective knowledge management' (p.1). A quick search for the meaning of the word ***knowledge*** reveals that defining the concept is not a straight forward exercise. This is evident in the three definitions highlighted below;

In the Merriam Webster's Collegiate Dictionary (2002), it is defined as;

> *'...an acquaintance with or an understanding of a science, art or technique'*

The Oxford English Dictionary defines it as;

> *'... acknowledging... recognizing... inquiring... being aware... understanding... cognizance... intelligence... information acquired through study, and learning'*

McInerney (2002) defines knowledge as;

> *'...an awareness of what one knows through study, reasoning, experience or association or through various types of learning'*

The meaning of knowledge also appears to be the subject of on-going disputes amongst philosophers. Davenport and Prusak (1998) describe this obsession as a lifetime occupation for some philosophers where they say '...epistemologists spend their lives trying to understand what it means to know something' (p. 5). They contend that rather than pretend that there is a definitive answer to what knowledge is it is better to look for '...a working definition, a pragmatic description that helps us communicate what we mean...' (p.5). This paper chooses to endorse this contention because it is believed that there is a danger of limiting one's understanding of what it means to know something when one chooses to belong to one camp. A much broader approach to the

understanding of knowledge such as that advocated by McInerney's (2002) and Davenport and Prusak (1998) is suggested. The former describes knowledge as a product of a varied set of processes which are constantly changing with human experience. In fact, from her definition of knowledge, it is clear that she makes an attempt to incorporate what can be argued to be important aspects of various theories of knowledge. McInerney's views, as will be seen later, are representative of the general views held within the discipline of knowledge management (KM) in particular those of Davenport and Prusak (1998). The next section reviews some of the thinking within the discipline of KM paying particular attention to the way knowledge is understood within this context.

Knowledge management

Keane and Mason (2006) observe that the discipline of KM has continued to receive the attention of both researchers and practitioners since its establishment in the mid 1990s. Its goal has generally been viewed as the application of technical and organizational capabilities to improve the processes of creating, storing, retrieving, transferring, and applying knowledge and greater a greater emphasis has been placed on the management of knowledge and the development of the channels through which knowledge and information flow, they note. Wilson (2002), however, finds that there is a broad range of thought on KM with no unanimous definition. He notes that as the discipline continues to gain recognition there appears to be an increasing presence of academic disputes within epistemology emerging in both the theory and practice of knowledge management. A comparison of these disputes with those identified earlier would be an interesting exercise. For example, it would be interesting to see if earlier epistemological debates have in any way influenced the way knowledge is understood within the context of KM. Unfortunately, such an exercise is beyond the scope of this paper. However, a brief review of some criticisms of the most popular school of thought is worthwhile. This should help pave the way for the discussion of the role played by artefacts in the transfer of knowledge from artefact to user.

The prominent school of thought on KM is that associated with the work of Davenport and Prusak (1998) and that of Nonaka and Takeuchi (1995). According to Keane and Mason (2006) this school of thought makes two assumptions. The first is that within KM there are two types of knowledge (tacit and explicit) and that knowledge management systems should focus on converting one type to the other. The second assumption is that there is an important distinction between knowledge and information. Their persuasive arguments as to why these two popular assumptions need revisiting are, unfortunately beyond the scope of this paper. It is, however, useful to point out that Nonaka and Takeuchi (1995) are implicated for holding that a successful KM program needs to convert internalized tacit knowledge into explicit codified knowledge in order to share it. To think this way, assert Keane and Mason (2006) is to suggest that for knowledge to be made explicit, it must be translated into information. This, oversimplification, they contend has resulted in the misconception that tacit and explicit are types rather than dimensions of knowledge. As with the second assumption, that there is an important distinction between information and knowledge and that the latter is at the top of the hierarchy (Tuomi 2000, Von Krogh,, Ichijo, and Nonaka 2000, Wilson 2002 and Davenport and Prusak, 1998), they caution that focussing on one as more or less superior to the other negatively impacts on the effort to manage knowledge.

This paper also finds problems with the distinction between information and knowledge. It is observed that this distinction is the outcome of the confusion between the two concepts. The definitions of terms by Davenport and Prusak's (1998) below offer grounds for criticism.

> '...information should be thought of as *"data that makes a difference" (p3),..."data endowed with relevance and purpose" (p2),... to inform' originally meant 'to give*

> *shape to'* ...Data is *"a set of [sic] discrete, objective facts about events"(p2)*...and that Knowledge, on the other hand, is much richer, it is:
> *"a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms." (p5)'*

In critiquing the above, it is acknowledged that the definitions of data and information are technical definitions used in computer technology and as such can be viewed as unproblematic in this context. However, a cursory examination of the philosophical grammar (Wittgenstein, 1974) of the three terms demonstrates that several aspects of their more general usage present possible obstacles and pitfalls in the way of further development. First, data are not necessarily only facts about events; they may be facts about objects or substances, such as the composition or physical properties of a particular steel girder, or concrete mix. They may also relate to spatial properties. Secondly, 'what is given' is not necessarily a discrete fact at all. It could, for instance, be a picture, a sound, or a feeling. A sounder definition of data therefore would be recorded information (given that it would have to have been seen to have some relevance to have been recorded in the first place)

Furthermore, while it is extremely useful to think of information as shaped data, it can also be misleading, if it is assumed that that is all information can be. Phenomenologists have pointed out that people not only shape facts in this manner, but give shape to the whole of the world we live in. Indeed, facts themselves are a product of the social processes by which people make sense of the world. In the real world of organisations, if one asks a colleague for information regarding a task they are about to perform, s/he is as likely to produce advice by drawing upon their experience, as upon any facts they themselves have been given. Davenport and Prusak (1998) implicitly recognise this when they refer to "contextual information" (p.5) in their definition of knowledge, but this leads them to a uni-directional characterisation of the grammar, such that "knowledge derives from information as information derives from data" (p.6). It might just as be said that data (facts) derive from knowledge (experience and thought) and thus, so too does information. It might also be said that sometimes information derives directly from experience, without the intervening process of producing facts. Further, information can be passed directly from one human being and another without being recorded as data.

Information is knowledge, but knowledge is not necessarily information. To explain this asymmetry of meaning, Ryle's (1963) distinction between ***knowing how*** and ***knowing that*** is adopted. To know how is to be able to do something, it is thus essential to a practice. The community of practice conception serves to highlight this second, important aspect of knowledge. Furthermore, it usefully stresses the social nature of this practice knowledge (Wenger, 1999). The conception of knowledge as social practice is particularly useful as the test for knowledge is always performative. Central to the KIM project "lies the contested distinction between knowledge and information" (KIM 2006). Davenport and Prusak's (1998) characterisation of knowledge as a process, rather than an artefact is adopted to provide a basis for working definitions. Thus, KIM addresses two major aspects of the knowledge and information management problem as it occurs in the move towards a product-service paradigm.

In an effort to clarify the confusion in the way knowledge is understood within KM a tri-partite approach to knowledge is offered. The tri-partite approach to knowledge is suggested by an apparent deficiency in the information/community of practice distinction used to formulate the KIM problematic. The suggested approach supplements the information and community of practice concepts with a conception of physical objects and environments as information carrying entities which are constituted, recognised and used in the course of social practices. The tri-partite approach

highlights the value of physical (including visual and tactile) properties of artefacts in the transfer of knowledge from artefact to user. The next part considers this third aspect of knowledge in detail. The aim is to establish that physical objects and environments have an important role to play in codifying, embedding and disseminating knowledge. Thus, the physical (including visual and tactile) properties of artefacts as bearers of knowledge are emphasised.

Researching knowledge embedded in the physical Properties of Artefacts

Physical properties of artefacts have always been utilised to store information. Computer databases are simply a particularly sophisticated and useful example of this. In production and operations management, attention has been given to the rendering of information in visual form and providing transparency to the work situation (Galsworth 1997; Hines, Francis & Found 2005), especially stimulated by the example of the Toyota Production System. Generally, it can be assumed that lack of transparency increases the propensity to err, reduces the visibility of errors, and diminishes motivation for improvement (Formoso *et al* 2002). Communication through the visual properties of artefacts has recently received attention also in a number of other fields observe. The *kanban* system uses physical placement of documents to facilitate improved production flow (Shingo 1988). *Poka yoke* (mistake proofing) involves the physical embodiment of assembly and operation knowledge in components and products. In aerospace, Dekker (2005) observes how the physical conditions and configurations of 'normal work' can contribute to an unnoticed drift towards system failure.

This research has recently analysed photographs of objects and environments to determine the nature in which knowledge is codified and embedded in them and how this knowledge is consequently disseminated. Codified knowledge in this context refers to information that is conveyed in signs and symbols (Collins, 1993) and embedded knowledge that which embedded in the physical properties of artefacts. The next section looks at some of the photographs showing examples of each kind of knowledge. All the photographs used have been taken by the researcher herself.

Codifying, embedding and disseminating knowledge

This section looks at some of the work the researcher has started to analyse. The examples chosen are a reflection on her own experience as a nurse, a patient and an ordinary member of the public. The first example is an account of how the researcher made sense of the hospital environment in order to find her way to the x-ray department. The second example illustrates how people can intuitively open a door without a struggle. The last example is an account of a breakdown in the transfer of knowledge in the maintenance of an oxygen gas cylinder. All the photographs used in this paper have been taken by the researcher herself. The research is intended to meet the criteria of the unique adequacy requirement, which is briefly described under the methodology section.

A visit to the x-ray department

This is a true account of the researcher's own experience as a patient in finding her way to the x-ray department from home. She will be referred to as Mrs R in this section. The letter inviting Mrs R for an appointment did not give much direction on how to find the way to the x-ray department. All it said was that the department was in the purple zone. As a result, she had to depend on the physical properties of artefacts plus information posted on signs to find her way in and around the hospital. Below is an account of how she managed to find her way from the time she got off the bus

outside the hospital.

As she got off the bus she saw an opening into the hospital grounds a few yards from the bus stop. This happened to be the only obvious opening so she assumed that it was the entrance she needed. Barely a few yards into the hospital grounds Mrs R was presented with the sign stating:

Unfortunately there was no further information to help Mrs R gain access to the main hospital. On exploring further, she soon found herself walking along an alley way with no clues as to where the entrance to the main hospital was. At the end of the alley she was suddenly in full view of the entrance to the hospital. It was clearly marked with colour coded signs one of which showed the direction to the *purple zone*. A few yards into the hospital corridor, she found yet another display of signs directing the user to various hospital departments. The directions for the x-ray department were on it.

Further in, she was presented with more signs of this nature, some hanging from a height and others stuck on the walls. The confusion occurred at a junction where the sign for the x-ray department pointed upwards. Mrs R automatically assumed that she was to take a lift to the floor above. However, the sign is intended to instruct the user to go forward. Unfortunately, it was not easy to find the way forward at this particular junction of the hospital because of curves, alcoves and corners. Three other people appeared to be struggling to find their way too. A hospital porter spontaneously offered to help, stating; '***Its double Dutch here***'

This example clearly shows that Mrs R used codified knowledge to find her way in and around the hospital. It is also clear that this kind of knowledge alone was not entirely effective in helping her find her way. Wayfinding specialists contend that putting up signs without strategy in complex environments sometimes has the opposite effect to that intended (Inside Information Ltd, 2008). This was certainly true in this case. The researcher intends to establish that complex environments such as hospitals can be embedded with knowledge which should make the task of finding one's way in and around the hospital an easy and pleasant one with minimum need for signs. Further analysis of Mrs R's experience, therefore, will seek to identify features that can be designed into or out of the two specific points where wayfinding became problematic for Mrs R. The first breakdown can be seen right at the beginning where there is no clear access to the main hospital. The second is at the junction where the instruction given by the sign pointing upwards is not supported by the architectural layout of that part of the building.

Opening a door

Think of the simple task of opening a door. How often do we try to open doors the wrong way even where there are clear instructions saying “Push or Pull”? Is it not also true that we feel stupid for having failed to see the written signs? Quite often people have chided themselves (silly me!) for having failed to spot the instruction giving signs. However, according to Norman (2002), well designed artefacts should be easy to interpret and understand. They should contain visible clues as to how they should be operated without the need for words or symbols and certainly without any need for trial and error (Norman, 2002). In the case of knowing how to operate a door, Norman contends that the correct parts should not only be visible but must convey the correct message. The

designer must provide signals that naturally communicate to the user where to push or pull.

A door with a vertical plate on one side and a handle on the other immediately communicates to the user the direction in which the door will open (see photographs below). This is a good example of how knowledge can be embedded in artefacts at design stage. The door is clearly instructing its user on how to perform the task without the need for explicit communication. The user performs the task without the need for trial and error. He or she is able to make sense of how to open the door without having to pay much attention to the task at hand.

Norman assures us that

> '*The human mind is exquisitely tailored to make sense of the world. Give it the slightest clue and off it goes, providing explanation, rationalization, understanding*' (p.2).

The oxygen cylinder

Healthcare institutions have an obligation to provide an effective resuscitation service and to ensure that their members of staff receive training and regular updates for maintaining a level of competence appropriate for them to resuscitate a patient in the event of a cardiac failure (Royal College of Anaesthetists *et al* 2004). It is the job of healthcare professionals to ensure that there is adequate oxygen in the cylinder and that it is not out of date. On a regular basis therefore, the cylinder must be checked for fullness and freshness. A replacement is necessary only when the oxygen is out of date or when the cylinder is less than half full. A label carrying the expiry date is attached to the cylinder by the manufacturer (see below). The life cycle of oxygen cylinders varies by manufacturer from 5-15 years.

In the incident involving the oxygen cylinder, a conscientious student nurse alerted the team to the fact that the cylinder was a year out of date. Here the researcher is interested in finding practical solutions to this breakdown in the flow of knowledge. Can this device be embedded with knowledge which should make it possible for nurses to know shortly before the long life span comes to an end? If so, what kind of knowledge can be embedded?

Research Methodology

The current research adopts an ethnomethodological approach to investigating how people make sense of knowledge embedded in the physical properties of artefacts. Ethnomethodology is a sociological approach distinct from traditional sociological approaches in that it concerns itself solely with **observable** features of social life (Francis and Hester, 2004). It focuses on how observable social activities are produced, accomplished and understood by ordinary members of society. Put in a different way, it is keen to investigate how members of society (individuals and organisations) make sense of and function in society by creating social facts or understandings of how society works. Thus, to understand how one finds their way to the x-ray department, the researcher must know what any member to that setting would ordinarily know about that setting. The researcher is able to perform relevant activities within that setting without censure from other members. Meeting this criterion satisfies the weak requirement of the unique adequacy (UA) criteria which stipulates that:

> *"the analyst must be vulgarly competent in the local production and reflexively natural accountability of the phenomenon" (*Garfinkel and Wieder 1992, p182)

By contrast, the strong requirement concerns the reporting of research (Rooke and Kagioglou, 2007). It demands that the methods of analysis used to report on, or describe a setting should be derived from that setting, that is to say, they should originate from the setting they describe (Rooke *et al*, 1997). In effect, UA stipulates the application of a policy of 'ethnomethodological indifference': a refusal to evaluate, describe or explain the activities that constitute the setting using criteria, concepts or theories that are not a part of that setting. This approach is chosen because it provides a framework for researching and analysing how people make sense of artefacts without relying on previous theories.

Findings and Discussion

The first part of this paper has reviewed various views held on the meaning of the concepts knowledge and knowledge management. The aim was to gain a clearer understanding of these key concepts in order to pave the way for the discussion of the important role played by artefacts in the transfer of knowledge throughout the life cycle of a product. The review has uncovered much dispute amongst philosophers, practitioners and researchers regarding both concepts. However, the position of this paper is that it is more important to pay attention to the practical pockets of advice suggested in these various disputes rather than to enter into them. For example, it is contended that in order to reduce the risk of limiting one’s understanding of the meaning of knowledge, especially

within KM, it would be more productive to see it as a product of a varied set of processes which are constantly changing with human experience. The review has also highlighted arguments to the effect that the distinctions between *tacit/explicit* and *information/knowledge* are faulty and misleading. A need for revisiting these distinctions is suggested, as these issues are at the core of KM and are said to be used wrongly to inform current KM programmes (Keane and Mason, 2006). In the case of the *information/knowledge* dichotomy, an alternative approach (tri-partite) to the understanding of knowledge within KM is suggested. The second half of the paper is an attempt to develop the third concept of the tri-partite approach to knowledge. The review shows that there is a small body of evidence in literature highlighting the value of the physical properties of artefacts in transferring knowledge within social processes. The initial findings of the current research show examples where artefacts successfully disseminate knowledge embedded or encoded in them. An example where there is a breakdown in the transfer of knowledge is also highlighted.

Conclusion and Further Research

The original intention of this paper was to investigate the role played by physical objects and environments in communicating knowledge to their users. This was inspired by the objectives of the KIM Grand project which recognises that more and more customers are increasingly demanding from manufacturers' products that can be supported throughout their life cycle. Thus organisations across all sectors need to move from product-delivery designs to product-service ones. This, therefore, calls for a further need to find best ways of communicating with users through artefacts. These ways should make it easy for customers to operate artefacts or within them without the need to run back to the producer every time a breakdown occurs. This research, therefore, suggests that embedding knowledge into artefacts in such a way that the intended knowledge is explicitly communicated to users is one way of ensuring that an artefact is supported throughout its life cycle. Doing so will require an understanding of what knowledge is and how it can be managed in the first instance.

The first half of the paper has shown that the two key concepts of knowledge and knowledge management continue to be debated amongst philosophers, KM practitioners and researchers regarding their scope and meaning. The review has uncovered several calls for a clearer understanding of and approach to these concepts. For example, Davenport and Prusak (1998) call for a working definition of what it means to know something on realising that disputing amongst philosophers has no end in sight. There is also a call by Keane and Mason (2006) for the unification of the broad range of thought on KM and a reconsideration of the current distinctions drawn between tacit/explicit and information/knowledge within this discipline. This paper calls for broader understanding and clarification of knowledge, information and data within KM. A tri-partite approach to knowledge is suggested as the solution to the confusion that there is in the way these three concepts are understood. The approach sees information, practice and artefacts as knowledge bearing entities and key to its effective transfer. The second half of the paper puts forward the early stages of the move towards developing the third concept of the tri-partite approach. It has shown that researching how knowledge can be codified or embedded in artefacts with a view to aiding explicit communication between user and artefact is currently under way. The earliest findings based on the researcher's own experience and an analysis of photographs of artefacts are beginning to show that knowledge can be embedded and encoded in the physical properties of artefacts in such a way that it can be explicitly communicated from artefact to user.

The issues highlighted in this paper suggest further work. The call for a reconsideration of the popular assumptions should not be ignored. Future work intends to look more closely at the philosophical arguments around tacit and explicit knowledge. The next level of fieldwork is a research opportunity in a hospital setting. The researcher is currently investigating how staff,

patients and visitors make use of knowledge embedded in physical objects and environments to find their way to, in and around hospital (Wayfinding). Future work intends to investigate how patients and staff use embedded knowledge to make sense of various hospital rooms (treatment rooms, toilets, etc.); enhance their hospital experience during a treatment episode (Patient care pathways); and maintain the hospital built environment and technical devices that are part of it.

Acknowledgements

The work presented herein was undertaken under the aegis of the Knowledge and Information Management (KIM) Through-Life Grand Challenge Project (www.kimproject.org) funded primarily by the Engineering and Physical Research Council (EPSRC – Grant No EP/C534220/1), the Economic and Social Research Council (ESRC – Grant No RES-331-27-0006) and University of Salford's Innovative Design and Manufacturing Research Centre (Salford Centre for Research and Innovation (SCRI) in the Built and Human Environment

References

Collins, H. (1993), "The structure of knowledge", Social Research, Vol. 60 pp.95-116

Davenport, T. H. and Prusak, L. (1997) Working knowledge; how organizations manage what they know, Harvard Business School Press, Boston, MA.

Dekker, S. W. A. (2005) 'Why we need new accident models' Technical Report 2002-02, Lund University School of Aviation.

Francis, D. and Hester, S. (2004) An Invitation to Ethnomethodology; Language, Society and Interaction, Sage, London.

Formoso C. T., Dos Santos. A., and Powell .J. A. (2002) An exploratory study on the applicability of process transparency in construction sites Journal of Construction Research, Vol. 3, No. 1 (2002) pp. 35-54

Galsworth, G. D. (1997) Visual Systems: Harnessing the Power of a Visual Workplace, American Management Association, and New York.

Garfinkel, H. and Wieder, D. L. (1992) 'Two Incommensurable, Asymmetrically Alternate Technologies of Social Analysis', in G. Watson & R. M. Seiler (eds.), Text in Context, Sage, London, pp. 175-206.

Hines, P., Francis, M. and Found, P. (2005) 'Lean Lifecycle Management,' Rooke, J., Koskela, L., Siriwardena, M., Ruikar, K., Kagioglou, M., Sexton, M., McDermott, P. and Aouad, G. (2006) CUIMRC Working Paper Series, University of Cardiff.

Hockey, J. and Collinson, J. A. (2006) 'Seeing the way: visual sociology and the distance runner's perspective,' in Visual Studies 21(1).

Inside Information Ltd, (2008) The A to B of wayfinding www.info.co.uk

Keane and Mason (2006) On the Nature of Knowledge: Rethinking Popular Assumptions Proceedings of the 39th Annual Hawaii International Conference on Science Systems, Volume: 7

KIM (2006) Knowledge and Information Management Grand Challenge Project www.ukoln.ac.uk/projects/grand-challenge/

McInerney., C (2002) Knowledge Management and the Dynamic Nature of Knowledge. Journal of the American Society for Information Science and Technology 53(12) pp.1009-1018

Merriam Webster's Collegiate Dictionary (2002), 10th http://www.google.co.uk/dictiionary Accessed on 17 October 2008

Nonaka, I. and Takeuchi, H., (1995) "The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation." New York, NY: Oxford University Press,

Norman, D. A. (2002) The Design of Everyday Things Basic Books New York

Rooke, J., Seymour, D. and Crook, D., (1997), Preserving Methodological Consistency: a reply to Raftery, McGeorge and Walters, Construction Management and Economics, 15 (5) pp.41-494

Rooke, J. A. and Kagioglou, M. (2007) 'Criteria for evaluating research: the unique adequacy requirement of methods', Construction Management Economics, 25:9, 979-987

Ryle, G. (1963) the Concept of Mind, Penguin, Harmondsworth.

Shingo, Shigeo. (1988) Non-stock production. Productivity Press, Cambridge, Mass

The Royal College of Anaesthetists, Royal College of Physicians of London, Intensive Care Society & Resuscitation Council (UK) (2004). Cardiopulmonary Resuscitation Standards For Clinical Practice and Training, Available on line at www.resus.org.uk

Tuomi,. I (2000 "Data is More than Knowledge: Implications of the Reversed Knowledge Hierarchy for Knowledge Management and Organizational Memory," Journal of Management Information Systems, vol. 16, pp. 103-117,

Von Krogh, G., Ichijo, K., and Nonaka, I. (2000) Enabling Knowledge Creation. New York, NY: Oxford University

Wenger, E. (1999) Communities of Practice: learning, meaning and identity, Cambridge University Press, Cambridge.

Wilson, T. D., (2002) "The nonsense of 'knowledge management'" Information Research, 8(1), paper no. 144. Available at http://InformationR.net/ir/8-1/paper144.html

Wittgenstein, L. (1974) Philosophical Grammar, Blackwell, Oxford