



‘Knowledge Management’: A Telling Oxymoron?

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INTRODUCTION

As organisations continue to seek optimal levels of competitive advantage and innovation, the search continues for more powerful and successful ways of achieving these goals. One such is the emerging discipline of Knowledge Management (KM). This is an approach, which is becoming firmly embedded in the panoply of management methods, as noted by Scarborough et al (1999), ‘Knowledge Management (and the learning organisation) represent important new approaches to the problems of competitiveness and innovation confronting organisations.’ These are not insignificant claims and, typically, pursuing them requires organisational investment, which is also substantial. This paper seeks to develop a critique of KM, with a view to supporting more informed theory and practice in this area. This critique is based upon recent empirical research (Sutton, 2000; Sutton and White, 2000; White and Sutton, 2000). The nature, methods, and key findings of that research are, therefore, briefly described here.

NATURE OF THE RESEARCH PROJECT

The research explored the nature of, and relationships between, knowledge, data and information in the context of clinical practice in the United Kingdom National Health Service (NHS). It focused on the nature of clinical knowledge and the large-scale statistical datasets, which are generated from healthcare activities and decisions. These datasets are used for significant and far-reaching decisions about NHS policy.

The genesis of this research was a growing interest into what appeared to be a paradox pertaining to clinical data in the NHS. The paradox involved the fact that, while to the lay eye medicine appeared to be a discipline imbued with all the rigour and certainty of science, key elements of clinical knowledge and data seemed often to be characterised by uncertainty and vagueness, and to be opinion-laden. In short, these elements seemed to be characterised by subjectivity at least as often as they were by objectivity. Yet both objective and subjective types of data were all somehow regularly transformed into a homogeneous body of objective, statistical ‘facts’, used by Government and various healthcare managers as the basis of significant decisions about healthcare in the NHS. Thus, this piece of research was developed and undertaken, in order to gain a better understanding of the nature of knowledge and data, and the underpinning social processes inherent in clinical care. This study sought to achieve its aim specifically by developing a better understanding of knowledge in the clinical context of the NHS and to achieve this by exploring the impact of social and organisational context, and transformation processes, on knowledge transferred between individuals and groups.

THE RESEARCH APPROACH

The research problem demanded an exploratory approach, which led, therefore, to the use of inductive methods. The key objective of the research approach was: ‘to describe, decode, translate or otherwise come to terms with the meaning, not the fre-

quency, of certain more or less naturally occurring phenomena in the social world’. Data collection was, therefore, undertaken partly by using ethnographic methods which involved the practitioner ‘participating covertly or overtly in people’s daily lives for a period of time, watching what happens, listening to what is said, asking questions - in fact, collecting whatever data are available to throw light on the issues that are the focus of the research’ (Hammersley and Atkinson, 1983). This extensive qualitative, field-based investigation included a long period of participant observation in clinical and coding settings, and thirty semi-structured interviews with senior clinicians, healthcare data statisticians and epidemiologists, administrative workers, healthcare managers and coders. This overall approach, of complex, discovery-based research yielding rich, qualitative data, produced a deep understanding of the processes and contexts involved in the domain of clinical decision-making. Data was analysed using Grounded Theory, as described by Glaser and Strauss (1973).

FINDINGS FROM THE RESEARCH

Conclusions from the research suggested that clinicians’ use of information and subsequent recording of data represents a highly personalised area of professional activity. This does not subsequently translate easily into coded schemes, including data sets and the statistical classifications that are in common usage in healthcare management. Thus the research challenged the validity of the relationship between this knowledge and its coded counterparts, arguing that the fidelity of the statistical data to the original clinical knowledge is apparent and not real. Consequently, the rationality of decisions made on this basis is equally dubious.

Turning now to the implications of this for KM, the research resulted in the following views of KM, which suggest that a range of factors militate against the current KM notion of ‘knowledge’ and how it might be ‘managed’. These are explored below.

WHAT IS KNOWLEDGE MANAGEMENT AND HOW DOES IT WORK?

KM is a concept that achieved increasing prominence throughout the 1990s. It essentially seeks to create a type of organisational ‘neural network’, wherein key knowledge possessed by individual workers is made more generally accessible. As noted by Blake (1998) ‘KM is the process of capturing a company’s collective expertise wherever it resides and distributing it to wherever it can help produce the biggest payoffs.’ (Blake, 1998 : 2). Such expertise, or ‘knowledge resources’ are defined as ‘core competencies’ (Prahalad and Hamell, 1990) or ‘routines’ (Nelson and Winter, 1982) ‘capabilities’ (Collis, 1991) and ‘core skills’ (Klein et al, 1991). These are seen as ‘... the well-spring of future product development the roots of competitiveness, and individual products and services are the fruit.’ (Prahalad and Hamell, 1990: 202). This is not restricted to those within an organisation: ‘(KM) is an approach to adding or creating value by more actively leveraging the know-how, experience and judgement residing within

and, in many cases, outside an organisation.’ (Ruggles, 1998: 82).

In terms of how KM harnesses these resources, ‘KM is equated to data mining, digging and drilling its aim is to ‘mine’ the tacit knowledge, skills and expertise of people.’ (Gardner, 1998: 24). Furthermore, the idea behind KM is to collect and make accessible workers’ knowledge ‘.... via a searchable application.’ (Cole-Gromolski, 1997: 6). Information technology is, therefore, a key enabler to KM: ‘KM is primarily IS/IT driven.’ (Scarborough et al, 1999: 27).

Typically in the KM literature the dimensions of knowledge types, which are addressed are tacit and explicit, subjective and objective. As evidenced by the objective of ‘mining’ and making accessible through searchable applications, all knowledge types are assumed ultimately to be accessible and codifiable.

In summary, therefore, KM classifies knowledge along two axes: subjective/objective and tacit/explicit. Furthermore it assumes no differences in the nature of these knowledge types, which would preclude its faithful representation via computers. It also assumes that knowledge can be fully and accurately articulated and transferred among different cultural groups: ‘(KM) depends on tapping the *tacit* and often highly *subjective* insights, intuitions, and hunches of individual employees and making those insights available for testing and use by the company as a whole.’ (Nonaka, 1998: 24).

KNOWLEDGE MANAGEMENT : A CRITIQUE

Methods of capturing and representing reality are operational manifestations of particular ontological and epistemological beliefs, and characteristic of a particular paradigm. This critique will, therefore, begin by exploring KM’s underlying paradigm, and will then consider the validity of its relationship to the kind of knowledge underpinning human expertise.

As indicated in the above description of the processes involved in KM, it is characterised by a scientific approach to knowledge and knowledge transfer, reminiscent of that found in Artificial Intelligence and Computer Science. As noted by Scarborough et al (1999:33) ‘.... the systematic use of knowledge for economic objectives is clearly a feature of Taylorism and related methods.’ Scientific methods are reductionist. Reality is perceived to be an immutable phenomenon; areas may, therefore, be fragmented without loss of emergent properties. This paradigm asserts that the world can be exhaustively analysed in terms of determinate data or atomic facts. The assumption that all knowledge can be faithfully represented in codes, and shared amongst individuals is a natural consequence of these beliefs. Thus, this ‘technocratic intervention’ (Scarborough et al, 1999: 50) can successfully divorce knowledge from its organisational context, and *all* that is relevant to intelligent behaviour can be formalised in a structured description (Sowa, 1994, Fiegenbaum and McCorduck, 1983). In this scenario coding schemes and computers are neutral knowledge transfer media. In other words, emergent properties (Checkland, 1981, von Bertalanffy, 1968) or properties that emerge at certain levels of complexity and cannot be reduced in explanation to lower levels (because they do not exist there) are not perceived to exist. Computer representation, therefore, requires only adequate identification and understanding of the various entities and relationships between them. Finally, there is an implicit belief, again reflecting this mechanistic paradigm, in a rational, unproblematic and predictable relationship between knowledge, data, information and decision-making.

That being the case, one might expect data about such a world to be, ‘... discrete, explicit, determinate...’ (Dreyfus et al, 1986: 188). This is precisely the kind of data required by digital computers: ‘.... otherwise it will not be the sort of information which

can be given to a computer so as to be processed by a rule.’ (Dreyfus et al, 1986: 118). This is echoed by Weizenbaum (1985) in reviewing the work of von Neumann (1958) who asserts that, if he were to be presented with a *precise* description of what the computer was required to do, someone could program the computer to behave in the required manner. The following sections investigate this possibility in the context of the above-mentioned research.

KNOWLEDGE AND THE INDIVIDUAL

In the NHS consultations occur between clinicians and patients, and some clinical data about those encounters is coded, using clinical classifications. It is also computerised. The resulting data sets form the basis of Department of Health data about these clinical events. As described above, the research explored the nature of the relationship between the original clinical knowledge and the representation of that knowledge found in the data sets. The underlying premise was that, if all clinical work conformed to scientific principles, and clinical knowledge represented hard, immutable ‘fact’, coding, classifying and computerising would be relevant activities. If, however, clinical work and knowledge did not conform to these characteristics, data produced as a result of these activities, and decisions that followed from that data, must be considered unsafe.

The research confirmed that clinical knowledge is not overwhelmingly characterised by hard immutable facts. As noted by Szolovits (1994:1), ‘Uncertainty is the central critical fact about medical reasoning. Patients cannot describe exactly what has happened to them or how they feel, doctors and nurses cannot tell exactly what they observe, laboratories report results only with some degree of error’. A number of clinical participants to the research confirmed this further, a typical comment being: ‘Most (diseases) are pathognomically very difficult to diagnose definitively. There are some; for instance blood sugar above a certain level is pathognomic of diabetes mellitus, but these (instances) are rare.’

As noted by Fox (1979) and De Dombal (1996) medical teaching reflects this. It is based on the recognition that an irreducible amount of uncertainty is inherent in medicine. Fox (1979) asserts that three basic types of uncertainty may be recognised. The first results from incomplete or imperfect command of knowledge available about the discipline of medicine. The second stems from limitations in current knowledge. The third can derive from the first two, and rests upon the difficulty in distinguishing between personal ignorance or incompetence and the limitations of present knowledge. Generally, the literature in this area makes clear that it is assumed that medical knowledge gained thus far must be regarded as tentative and subject to constant further enquiry, and that few absolutes exist. It reveals medicine as something less than an exact science. Indeed, it reveals it as being as much an art as a science, a matter of judgement as well as skill. Notably, judgement, in the same way as art, is about subjectivity and interpretation, not empiricism. This immediately raises questions about the knowledge types recognised within KM, which can now be seen as insufficient. To subjective/objective and tacit/explicit must be added uncertain/certain.

In addition, knowledge that is uncertain may also turn out to be incomplete. As noted by a clinical participant: ‘Conclusions, including written ones, are usually tentative i.e., ‘found lying on the floor-?’, ‘fracture leg of femur?’, ‘cerebral haemorrhage?’.’ The question mark here was routinely used in clinicians’ handwritten medical records to denote these were options the clinician was considering, one, many, or none of which might turn out to be relevant. As another clinical participant remarked: ‘Often the clinician never has a clue why the patient is on the floor and often

they never find out.' Even so, as noted by Szolovits (1994:1) '.... we must make important decisions about testing and treatments and, despite our uncertainties about the bases of those decisions, the decisions themselves must be definitive.' Thus, the clinician is trained to act independently and confidently on the basis of the information available or acquirable, even where certainty or completeness are not possible, and where clinical findings and the totality of those findings remain tentative, subjective and heterogeneous to an unquantified degree. The KM classification of knowledge types must, therefore, be further extended to include complete/incomplete. Individuals have been shown still to make sense with, and act upon, vague, uncertain and incomplete knowledge.

The literature further indicates that a wide range of factors can then affect this basic uncertainty, extending the heterogeneity of clinical knowledge. Levels of acquired competence and skill affect uncertainty, as do levels of 'experience' generally. Experienced clinicians tend to elicit less information than their more junior colleagues, but they also tend to elicit more relevant information. They are also able to combine these items of information more appropriately than their juniors. Clinical experience generally operates as a weighting function that gives preference to these more effective types of connections. As discussed by Kluge (1996: 88) '.... these weighting functions are integral to the conceptual framework of the clinician as the clinician gains experience.' This was further explained by a clinical participant to the research: 'The clinician starts with two main groups of knowledge, prefaced by locational knowledge the setting confers some knowledge, i.e. if I know the patient will be in Outpatients I immediately assume they cannot be too sick. If I am scheduled to see them at home I assume they may be quite ill, or they would have been scheduled to attend Outpatients.' That type of knowledge can then be seen to nest within the two main groups which he went on to describe as: '.... general knowledge and experience, which can apply to all patients, and consisting of formal knowledge: that which has been taught to me, and informal knowledge: that which has been gained through experience, (and) specific knowledge about each individual patient, gained from personal consultation and communications' This was confirmed by another clinical participant, who remarked: '.... the basis of clinical medicine is an amalgam of others' knowledge and personal experience.' Thus the knowledge clinicians bring to each consultation was seen to be variable in quantity, quality and nature, and its application, within the broad, standard framework of clinical examination and history taking etc., was seen to be equally variable.

The next stage in the process of knowledge generation and application was described, again by a clinical participant, as follows: 'Following the initial discussion with the patient I take the data collected and put it to my personal knowledge base and conclude a number of things about the present state of the individual But what I conclude may be very different from what another clinician, faced with the same data might conclude' Thus 'weighting functions' or each clinician's unique psychological characteristics, are also influential in determining the reality perceived and represented. As noted by a clinical participant to the research: 'The other day a colleague of mine reported feeling a hard liver edge in a patient. My own examination indicated this was not so.' A second participant echoed this. Discussing a recent consultation he advised that his colleagues: '.... would be quite likely to go about the consultation differently and may even come to different conclusions, depending upon a number of factors, including the patient's personal characteristics, the relationship established, the Consultant's interests, experience, demeanour, etc.'

The practical consequences of this conceptual framework

are further enlarged upon by De Dombal (1996) particularly if, as discussed above, uncertainty is taken to mean not holding objective characteristics, i.e. not being hard, immutable 'fact'. In discussing the need to abandon simplistic models of clinical perception and information when designing computerised clinical information systems, De Dombal comments on factors affecting the objective value of a piece of clinical information. He presents an equation composed of a number of elements, which he asserts are not, so far, taken account of in either current determinist theory, current probabilist teaching or decision support systems. The equation includes the evidential value observed in previous surveys; the degree to which the local circumstances reflect the findings in various surveys; the confidence with which the clinical feature was elicited; the overall reproducibility of the process of elicitation of that feature; the clinical acumen of the individual eliciting the information; the relevance of the information to the role of the individual in the overall healthcare delivery system; and the timeliness of the information to the situation. De Dombal presents these factors as a list, indicating that, whilst he believes they influence the objective value of a piece of information, there is at present no knowledge of how they influence the value or how to combine them. What De Dombal is saying is that there is an acceptance, or belief in, simplistic representations of knowledge, 'such as clinicians' expressed opinions' (De Dombal, 1996: 1) but reality is much more complex than this. It is argued here that the characteristics of KM described above indicate an assumption of such simplicity. As De Dombal argues, reality is more complex. It is not only more complex for the reasons he states, but also because, as discussed below, expressed opinions rarely constitute firm ground for accurate representation of knowledge.

'MINING' CAPTURING AND TRANSFERRING KNOWLEDGE

The notion of 'mining knowledge assumes certain abilities on the part of the holder of knowledge and the person extracting it, which it is argued here are without substantial foundation. Assertions here draw on work by Dreyfus et al (1986) who studied the learning process in humans to ascertain how far digital computers can safely go towards apparent 'intelligence'. Five stages are identified: novice, advanced beginner, competence, proficiency and expert. The novice is usually working on context-free information, i.e. not referring back to experience but learning by rote. The expert knows what to do on the basis of mature and practised understanding, with skill that is so much a part of them they are almost unaware of it. Dreyfus argues that this shows a progression from the analytic behaviour of a detached subject, consciously decomposing his environment into recognisable elements and following abstract rules, to involved skill-based behaviour involving holistic pairing of new situations. Thus a progression is seen, going from exercising no judgement to exercising judgement. Within this context, KM assumes that the user 'domain expert' is someone who possesses and, more importantly, can articulate 'know-that' knowledge and also 'know-how' with respect to how those beliefs became accepted within that domain, hence all that is necessary to capturing and sharing key knowledge can be gleaned from them. Work by both Dreyfus (1986) and Giddens (1976, 1984) refutes this. When discussing the consciousness of the acting subject they assert that much of human knowledge is, in fact, held by some to exist on a tacit basis. Dreyfus argues that the level of articulation required by the domain expert would require an unproven ability to regress from the state of tacit knowledge to that of the novice, who is conscious of the relationship between decisions, knowledge and data. Work in the field of KM by

Scarborough et al (1999) and Nonaka (1994) which further supports the existence and importance of tacit knowledge, also asserts that it forms part of the background of shared assumptions on which culture is founded and as such *cannot* be articulated. This is not necessarily perceived to be a problem to KM practitioners.

The perception of clinical work described here led to a conclusion that it is a domain in which the universe of discourse is imperfectly understood. Perception, knowledge and information, methods of describing observations and views of elements of it remain, even after clinical training, subjective and heterogeneous to an unspecified degree. This is not to say that there are no definitives, simply that no work was found which analyses types of clinical knowledge in such a way as to define which phenomena fall into which category and what the relative percentages are.

Despite this, the Department of Health believes it holds objective, factual data about key clinical events within the NHS, and bases decisions on it. Thus KM notions that such knowledge can be comprehensively captured and is codifiable and transferable are clearly suspect. When IT applications are applied to areas of human expertise, they go beyond the kind of context-independent, rule-driven, objective features of the real world relevant to their design principles. Ensuing data then provides only a flawed representation of the area of reality addressed.

SUMMARY AND IMPLICATIONS FOR KNOWLEDGE MANAGEMENT

The research underpinning and discussed in this paper demonstrated that, as noted by Blackler (1995), '.... knowledge is multifaceted and complex, being both situated and abstract, implicit and explicit, distributed and individual, physical and mental, developing and static, verbal and encoded.' It has also shown, using the domain of medical practice, that there are areas of knowledge where formalisation is inherently problematic, due to a range of social factors. As noted by Clancey (1995: 8) '.... medical practice is inherently unformalizable and truth-constructing, and that doesn't fit with the objectivist view of classic science.' As discussed by Kay and Purves (1996) and Kluge (1996) the personal consultation is: '..... not an interpretationally neutral fact gathering exercise, because it involves something other than a neutral information transfer this entire process carries its own phenomenological burden ... the physician ... records ... information with an ineluctable phenomenological bias.' (Kluge, 1996: 88). Clinical knowledge results, therefore, from enactment by clinical and non-clinical groups of their respective social contexts. These can be defined as knowledge-creating contexts, which determine how data might be both produced and also how it might be validly used in decision-making, both within and outside the domain of clinical work. Ability to translate such data in such a way as to transfer such knowledge across social boundaries, without disturbing meaning is questionable. Clinical data can, *technically*, be readily translated into data, and that data can be shared. However, accurate technical performance does not necessarily equate to transfer of knowledge. Rather this process gives a partly illusory and misleading representation.

In summary, the kinds of rationalist assumptions about knowledge creation and use, which characterise KM, are inadequate. Knowledge and meaning cannot be transferred as easily as data. The current approach adopted by KM is, therefore, simplistic, limited in scope and somewhat naïve. It is suggested that a broader approach to, and definition of, 'knowledge' is not only possible in this context, but an essential pre-requisite to attempts to harness and exploit it. It is also suggested that KM must have a social dimension if it is to realise its potential. If it is to avoid

being consigned to the ranks of yet another 'management fads' it must recognise and address the issues raised by the fact that knowledge is socially-located and constructed and cannot successfully be detached from the social context within which it is created and operates.

REFERENCES

- Blake, P. (1998) 'The knowledge management expansion' *Information today* 15 (1) 12-13
- Blackler F (1995) 'Knowledge, knowledge work and organisations: an overview and interpretation', *Organisation studies*, 16, (6) 16-36
- Bertalanffy, L. von (1968) *General system theory* New York: Braziller
- Checkland, P. (1981) *Systems thinking, systems practice* Chichester: John Wiley & Sons
- Clancey, W.J. (1995) 'The learning process in the epistemology of medical information' *Methods of information in medicine Special Issue* 1-16
- Collis, D. (1991) 'A resource-based analysis of global competition; the case of the bearings industry' *Strategic management journal, Summer Special Issue* 12 49-68
- Cole-Gromolski, B. (1997) 'Users loathe to share their know-how' *Computerworld* 31 (46) 6
- De Dombal, F.T. (1996) 'Assigning value to clinical information - A major limiting factor in the implementation of decision-support systems' *Methods of information in medicine* 35 1-4
- Dreyfus, H.L. and Dreyfus, S.E. (1986) *Mind over machine, the power of human intuition and expertise in the era of the computer* New York: The Free Press
- Feigenbaum, E. McCorduck, P. (1983) *The fifth generation: artificial intelligence and Japan's computer challenge to the world* Reading, MA: Addison-Wesley
- Fox, R.C. (1979) *Essays in medical sociology, journeys into the field* New York: John Wiley & Sons Inc
- Gardner, D. (1998) 'Knowledge that won't fit the database - people' *Infworld* 20 (14)
- Giddens, A (1976) *The interpretation of cultures* New York: Basic Books
- Giddens A. (1984) *The constitution of society, outline of the theory of structuration* Cambridge: Polity Press
- Glaser, B. G. and Strauss, A.L. (1973) *The discovery of grounded theory. Strategies for qualitative research* Chicago: Aldine
- Hammersley, M. and Atkinson, P. (1983) *Ethnography principles in practice* London: Routledge
- Kay, S. and Purves, I.N. (1996) 'Medical records and other stories - a narratological framework' *Methods of information in medicine* 35 72-87
- Klein J.A., Edge, G.M., Kass, T. (1991) 'Skill-based competition' *Journal of general management*, 16, (4) Summer, 1-15
- Kluge, E.H.W. (1996) 'The medical record: narration and story as a path through patient data, editorial commentary' *Methods of information in medicine*, 35 88-92
- Nelson, R. and Winter S. (1982) *An evolutionary theory of organisational change* Cambridge, MA: Harvard University Press
- Neumann, J. Von, (1958) *The computer and the brain* USA: Yale University Press
- Nonaka, I. (1994) 'A dynamic theory of organisational knowledge creation' *Organisation science*, 5 14-37

- Nonaka, I. (1998) 'The knowledge-creating company' [in] *Harvard business review on knowledge management*, Boston: Harvard Business School Press
- Prahalad, C.K., and Hamel, G. (1990) 'The core competencies of the corporation' *Harvard business review* May - June, 79-91
- Ruggles R (1998) 'The state of the notion: knowledge management in practice' *California management review* 40 (3) 80- 89
- Scarborough, H., Swan, J., and Preston, J. (1999) *Knowledge management: a literature review* London: The Institute of Personnel and Development
- Sowa, J. (1994) *Knowledge representation* USA, book in draft
- Sutton, Y.M. (2000) 'Knowledge transformation and representation: towards more informed provision and use of information' *PhD thesis, Sheffield Hallam University United Kingdom*
- Sutton, Y.M. and White, D.A. (2000) 'The representation and use of clinical knowledge through healthcare information systems in the UK National Health Service' *Proceedings, 33rd Hawaii International Conference of Systems Sciences* Jan 2000
- Szolovits, P. (1994) 'Uncertainty and decision-making in medical informatics' *Proceedings, Conference of the American medical informatics association 1994* 1-30
- White, D.A. and Sutton, Y.M. (2000) 'Achieving data quality: beyond rules and standards', *Proceedings of the BCS Healthcare Computing Conference*, Weybridge; BJHC Limited (2000) 236-242
- Wiezenbaum, J. (1985) 'The myths of artificial intelligence' [in] Forrester, T. *The information technology revolution* Oxford: Blackwell

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