The Limits of Disembodied Knowledge: Challenges of Inter-project Learning in the Production of Complex Products and Systems

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INTRODUCTION

Recent years have seen a growing interest in the nature of organisational knowledge and the possibilities for its active management. Contributions to this debate have come from many different quarters, both academic- and practitioner-orientated, drawing on a variety of insights from such areas as organisational learning (Argyris and Schön, 1978; Easterby-Smith, 1997; Senge, 1992), the 'knowledge economy' (Drucker, 1993a; 1993b; Thurow, 1999), the core competencies debate and resource-based theories of the firm (Amit and Schoemaker, 1993; Connor and Prahalad, 1996; Prahalad and Hamel, 1990), evolutionary economics (Marengo, 1992; Nelson and Winter, 1982; Winter, 1987), neo-institutionalism (DiMaggio and Powell, 1983; Powell and DiMaggio, 1991), the sociology of scientific knowledge (Ashmore, 1989; Latour, 1999; Pickering, 1996), and information systems and artificial intelligence (Bailey, 1997; Dutta, 1993; Fayyard *et al.,* 1996; Johnson, 1988; Speel and Aben, 1998). Out of this diversity (and the above list is by no means exhaustive), it appears that the discussion has crystallised around a series of key themes. Providing a touchstone for these is the claim that within organisations there "lies, unknown and untapped, a vast treasure house of knowledge, know-how and best practices" which, it is argued, can contribute a significant source of added value and competitive advantage providing they are 'leveraged' (O'Dell and Grayson, 1998, 154). This in turn prompts what has arguably become one of the central questions raised by the knowledge management (KM) literature: how far and through what means is it possible to tap into this fund of under-exploited organisational knowledge?

The responses to this question have been varied. There are those, for example, who assign a privileged position to new information and communication technologies (ICTs). These are regarded as providing new possibilities for capturing and transferring knowledge through dispersed organisational networks, a view most often supported, not surprisingly, by information technology groups within organisations and companies who supply KM software applications (Clark, 1998; Lotus Development Corporation, 1998; Moad, 1998). The ICT-led approach to KM tends to be founded upon the following key epistemological assumption: that while there are important tacit, implicit and routinised dimensions to knowledge and action within organisations, it is nevertheless possible and desirable to capture such knowledge by converting it into an explicit, codified, and effectively disembodied or depersonalised form. Once uncovered and codified, it is then possible to share this knowledge across the pathways of digital networks.

While ICTs have undoubtedly opened up new possibilities for the storage, transfer, retrieval, and processing of information and data, there are those who remain unconvinced by the enthusiastic claims made by ICT-led KM approaches for such technologies. A comprehensive critique has been directed at the epistemological underpinnings of these approaches, drawing attention to the limits of codification strategies arising from the understanding that much tacit and implicit knowledge is not susceptible to being 'surfaced' in the way suggested above, remaining instead beyond the reach of explicitly constituted communicative practices. ICT-led approaches have further been criticised for prioritising an *epistemology of possession* (Cook and Brown, 1996) whereby knowledge is treated as an object which can be captured, packaged, and shunted around at will. Accordingly, KM appears as a

largely technical issue of how to extract appropriate information and deliver it to where it is needed. This leads to an impoverished understanding of the crucial social dimensions of knowledge as situated, contingent, and context-dependent, constituted through negotiated processes of inter-subjective meaning formation and shaped through mutually intelligible communicative practices (Blackler, 1995; Gherardi, 1999; Orlikowski and Yates, 1994). Furthermore, an epistemology of possession promotes a static portrayal of knowledge-as-object which diverts attention away from *knowing* as a dynamic activity involving the continuous creation, reproduction, modification, and destruction of streams of meaning.

Although challenges to the ICT-led version of KM have by no means gone unheard, there are nevertheless indications that attempts by many organisations to implement KM programmes remain focused on codification, driven by an epistemology of possession, rather than fully exploring the implications of the social embeddedness of knowledge (e.g. Ruggles, 1998; Scarbrough *et al.,* 1999). This paper provides support for this assertion by drawing on initial results emerging from a study investigating inter-project learning in the production of complex products and systems (CoPS) being conducted by the CoPS Innovation Centre.[1] Examples include telecommunications networks, process plants, flight simulators, air traffic control systems, aircraft and avionics systems, large civil engineering schemes, and intelligent buildings.

KNOWLEDGE MANAGEMENT AND MANAGEMENT KNOWLEDGE

Given the frequent claim that KM is just another management fad, accounts of KM can often be found accompanied by a defensive caveat stating that the management of organisational knowledge is a long-standing, if not ever-present, dimension of organised human activity (e.g. Hansen *et al.,* 1999). In some instances, attempts to demonstrate the provenance of KM verge on the pedantic, coming perilously close to the banal, as with the suggestion by Pemberton (1998, 58) that there is nothing new about attempts to understand knowledge: "How can KM be the 'latest thing' when Aristotle and his predecessors spent so much time thinking and teaching about knowledge some two thousand years ago?". Others look to the more recent past to unearth the roots of KM. Stewart (1995, 209), for example, argues that "[c]ompanies have always tried to organize knowledge; they write handbooks, maintain files, provide training, and collect data".[2] There is, of course, a worthwhile message contained within such statements of the apparently obvious. Knowledge and knowing are indeed central, if not defining, human attributes, which lie at the core of social action. However, it was arguably not until the emergence of KM as a popular management idea, and distinctive (if variable and contested) set of practices, that the character of organisational knowledge began to be considered in any explicit way within management discourse. In this sense, what is novel about KM is not the fact that knowledge/knowing have suddenly become key aspects of organisations as

[1] This project is funded by the Engineering and Physical Sciences Research Council (EPSRC) and is entitled "Improving Performance in Complex Product System Performance via Inter-Project Knowledge Capture and Transfer"

[2] Some earlier uses of the term 'knowledge management' can also be found (e.g. Gates, 1975; Goerl, 1975; Henry, 1974; 1975).

complexes of social activity, but rather that 'knowledge' has become an important hermeneutic category through which organisational actors express an understanding of what they do, which in turn has implications, albeit often circuitously and incompletely, for their actions (c.f. Bhaskar, 1979; Sayer, 1992).

This self-referential spiral of meaning, involving knowledge about knowledge[3] with the potential for infinite regress, raises a number of difficult conceptual challenges, one of which is trying to disentangle the problematic relationship between knowledge, consciousness, and action. It is no longer possible, if it ever was, to view this as a straightforward and linear progression from knowledge to action and back again, where clear-cut distinctions can be made between the realms of ideas and practice. In addition, the unbreachable Cartesian dualism between subject and object has been brought into question. In part, this represents the unfolding of another chapter in the critique of the orthodox role of intellectuals as detached, disinterested, and supposedly objective arbiters of valid knowledge (c.f. Bauman, 1989; Bourdieu, 1988). Indicative of this view are challenges to the claims of privileged knowledge made by certain groups. Thus, knowledge about knowledge is no longer the exclusive preserve of philosophers and social theorists. It is increasingly appearing within discourses of management. Indeed, there are times when conventional claims to privileged knowledge are simply inverted:
"This [KM] is a movement born within industry - not the academic corridors or even the consulting firms. In fact, those parties are playing catch-up trying to determine their own role in this emerging economy" (Amidon, 1995, 4).

Just because privileged insights inaccessible to other groups are averred, this does not mean that validity claims made within practitioner-orientated (or any other) accounts of KM should be immune to critical evaluation. There is much to be learned here from debates within the sociology of scientific knowledge. These have indicated the importance of regarding such knowledge as socially and institutionally constructed, mediated by artifacts such as the technologies of observation and measurement, and emerging through intensely political relations within scientific communities bound together by common codes of practice, shared norms, systems of meaning, and epistemic traditions (e.g. Latour and Woolgar, 1979).
In a similar way, the emergence and evolution of KM discourses can be located within a particular set of socio-institutional relations and practices through which claims and counter-claims for and against the legitimacy of different ideas and assumptions are played out. Thus, it is important to be sensitive to the diverse and intersecting networks within and through which KM discourses are formed, diffused, and contested under varying conditions of power and influence. Participants in such networks include managers and employees with different sectoral and functional backgrounds (e.g. IT, human resource management, accounting and finance, project management etc.), consultants, professional and business institutions, governments, academics, and the media.

It is, of course, misleading to depict such groups as overly distinct, homogeneous, and undifferentiated. The boundaries are often blurred and overlapping, sometimes

[3] Foucault (1970, 353-355) captures something of this by suggesting that the human sciences are in a *position of duplication.*

intersecting within particular individuals, as with academics involved in consulting, or managers entering academia. Equally, it is incorrect to assume a direct correspondence between membership of a particular group and individual identities and beliefs. To take a relevant example, not all IT managers exhibit a systems orientated, technologically-led, dehumanised view of the world (although some would argue many do). Bearing these complexities in mind, the point is that different contributors to KM discourses are consciously or unconsciously supporting different sets of interests, following certain predilections, and pursuing different rationalities. These in turn influence the particular understandings attached to the interpretation of organisational knowledge and the possibilities for its management. The Habermasian concept of *knowledge-guiding interests* seems appropriate here (Habermas, 1984; 1989). However, it is important, in qualification, to emphasise the frequently unstable, non-unitary, and relatively unformed character of such interests, as well as the potential for different and sometimes directly competing rationalities to coexist within apparently coherent groups and even within individuals (c.f. Katz, 1992; Marshall and Bresnen, 1999). This insight is relevant in the current context because it helps to shed light on one of the paradoxes of KM suggested by the literature and emerging from the authors' current research into knowledge practices in the production of complex products and systems. The paradox is as follows: given the increasing recognition among practitioners of the limits of codifying, externalising, and depersonalising knowledge, why are many organisations nevertheless concentrating precisely on such activities at the expense of more socially embedded approaches? Before attempting some possible answers to this question, we now turn to examine some of the evolving themes in the KM literature to provide a conceptual basis for evaluating the claims and counter-claims surrounding the codification of knowledge.

OBJECTIFYING, COMMODIFYING AND CODIFYING KNOWLEDGE

The majority of accounts dealing with KM are framed by a common understanding that the successful development of organisational capability in this area is closely linked to achieving sustainable competitive advantage in what are regarded as turbulent and rapidly changing conditions in advanced economies (Bartlett and Ghoshal, 1993; Bontis, 1996). Often paying homage to the work of Bell (1973), there is general agreement that these economies have undergone (or are undergoing) a qualitative shift from a situation where physical factors of production and tangible assets (capital, labour, land) dominate, to one where knowledge is the dominant asset (Boisot, 1998; Drucker, 1993a; 1993b; Thurow, 1999).

Also associated with this depiction of recent socio-economic transformations are resource-based theories of the firm. Here it is argued that knowledge held by organisations can be a more enduring strategic asset than other more tangible assets because it is often difficult for other firms to imitate it, thus holding the possibility for generating economic rent over an extended period (Barney, 1991; Teece, 1998). The difficult-to-replicate character of certain types of knowledge in resource-based theory derives from at least three conditions associated with human assets: asset specificity, social complexity, and causal ambiguity (Coff, 1997). Asset specificity in firm-specific human assets refers "to special skills, knowledge, or personal relationships

that are only applicable in a given firm", which often assume a tacit form (Coff, 1997, 377). Social complexity and causal ambiguity refer to the embeddedness of organisational actors in complex social systems and the indeterminacies and limits to formal understanding of many social and cognitive processes (Hedlund, 1994; Lippman and Rumelt, 1992). While these conditions may provide organisations with a competitive advantage which is difficult for other firms to undermine through imitation, Coff (1997) goes on to argue that these same conditions also make firm-specific human assets difficult to manage.

Many proponents of KM accept resource-based theory's argument concerning the competitive potential of knowledge which is difficult to replicate. However, they are rather more sanguine about being able to overcome the barriers to the management of such intangible resources. The argument typically proceeds along the following lines:

> Knowledge management hinges upon the precept that the workers within an organization possess knowledge that can be converted into concrete business improvements if that information is harvested and disseminated to others to whom it would be of use. (Scheraga, 1998, 3).

> If tacit knowledge can be captured, mobilized, and turned into explicit knowledge it would then be accessible to others in the organization and enable the organization to progress rather than have its members having to relearn from the same stage all the time. (Gore and Gore, 1999, 556).

Providing a mantra for such accounts is the frequently invoked lament voiced by Jerry Junkins, the former chairman, president, and CEO of Texas Instruments: "If only TI knew what TI knows" (O'Dell and Grayson, 1998, 154). Organisations are depicted as fecund storehouses of localised knowledge held by individuals and groups, yet this knowledge remains under-utilised because it is not available to the organisation as a whole. Following this line of argument, the key issue becomes one of identifying the knowledge that resides within the organisation, finding a way to capture it and convert it into a form that can be transferred, and then making it available so that it can be used where needed. In effect, there is a search for economies in the use of knowledge where the time and cost of producing and using knowledge are reduced by recycling what has already been learned.

This portrayal of KM reveals an understanding of the nature of knowledge which can be characterised through the following three interlocking dimensions: objectification, commodification, and codification. Objectification refers to the tendency in many accounts of KM to endow knowledge with the ontological status of an object. Drawing inspiration from the philosophical tradition of American pragmatism, Cook and Brown (1996, 12) argue that deeply entrenched in Western modes of thinking is an *epistemology of possession* where "knowledge is seen as something that ultimately is always about what is in the heads of individuals, what is possessed by them, and as something that is best captured and represented in a form that can be stated directly, formally, objectively". If knowledge is something which can be possessed and yet, at the same time, can be expressed formally and explicitly, then it follows that it can also be abstracted from individuals, recorded, stored, moved about, and reused whilst remaining intact and unchanged. The information systems metaphors of data capture, storage, transfer, and retrieval, which pervade many KM accounts, are strongly suggestive of just such an epistemology and promote the view of knowledge-as-

object. Some even use the term 'knowledge objects' to refer to discrete parcels of information held within organisational databases. Clark (1998, 60), for example, defines these as "knowledge granules created by specialists throughout an organization ... that are accessible to many others in the organization ... small bytes of stored information ... tagged in databases in such a way that they can be assembled into flexible structures". Knowledge is depicted as a thing; something one can draw a definite boundary around; something that can be parcelled up and moved about.

The objectification of knowledge also tends to support the second dimension: the commodification of knowledge. It is only a small step from thinking of knowledge as an object to thinking how much 'it' can be sold for, or how much value 'it' contributes. The concern of KM is not with knowledge in general, but instead with productive knowledge, knowledge that creates value for the organisation. There are close parallels here with the notion of intellectual capital. Stewart (1995; 1998), who has been a popular exponent of ideas relating to intellectual capital in the business press, regards knowledge not only as an input incorporated into products and services, but also as a product in its own right. "Thinking of knowledge as a product helps you begin to develop a strategy for selling it" (Stewart, 1998, 254). Endowing knowledge with an object-like existence often appears to be considered a precondition for valuing intellectual assets, of which there have been a number of well publicised attempts. One of the most cited of these is the practice by Skandia, a large Swedish financial services company, of appending of the results of an intellectual capital audit to its annual report to shareholders (Edvinsson, 1997; Edvinsson and Malone, 1997).

The example of Skandia actually exhibits an important element of sophistication which belies cruder attempts at knowledge objectification, particularly in the recognition that intellectual assets can be decomposed into human capital, structural capital, and relational capital. Human capital refers to the skills, knowledge, and competences of employees; structural capital refers to the routines, systems, procedures, and culture which provide the context within which the potential of human capital assets is supported or constrained; and relational capital refers to the network of connections with customers, suppliers, and institutions. However, in mapping these different forms of intellectual capital through a variety of metrics (e.g. per capita training expenditure, education levels, employee turnover, IT capacity, IT literacy), and in assigning a financial value to intellectual assets, in the end the process of arriving at a formal statement of the company's intangible assets involves the choice of proxy measures which inevitably focus on tangible and objectifiable characteristics. The implication in the case of the human capital dimension, for example, is that the organisation is depicted as being ~~a~~ made up of (albeit changing) bundles of skills, knowledge, and competences, a stock of assets that might need updating or rebalancing, but effectively a collection of object-like entities. As we shall see below, there are important limitations to "treating knowledge like any other asset on the organization's balance sheet" (Davenport *et al.*, 1997, 8; c.f. Sveiby, 1997).

Objectification and commodification are in turn related to the third dimension: the codification of knowledge. It is intriguing given the increasing number of taxonomies of knowledge that clearly identify it as a complex, differentiated, and multifaceted construct, that so much of the debate surrounding KM has focused rather narrowly on

the relationship between tacit and explicit knowledge and the possibilities of codification. Alternative, although frequently overlapping, knowledge taxonomies can be broadly distinguished according to whether they concentrate on the focus of knowledge, its locus, or a combination of the two.

Typologies concerned with the focus of knowledge distinguish different forms of knowledge according to what it is about or what it refers to. For example, Millar *et al.* (1997) categorise knowledge into: 1) catalogue knowledge, or know-what; 2) explanatory knowledge, or know-why; 4) process knowledge, or know-how; 5) social knowledge, or know-who; and 6) experiential knowledge, that is to say, knowledge accumulated through engagement in past activities which may take any of the previous forms.

Typologies focusing on the locus of knowledge are less concerned with its referential character and more interested in where it is situated. Blackler (1995), for example, distinguishes between: 1) embrained knowledge, knowledge centred around human cognitive processes which is individualised, conceptual, and abstract; 2) embodied knowledge, knowledge centred on the perceptual engagement of individuals in action which is largely implicit, context-dependent, and performative; 3) encultured knowledge, knowledge centred on shared values, norms, and understandings which emerges through social interaction grounded in a range of communicative practices within cultural systems; 4) embedded knowledge, knowledge which is retained in systems, procedures, and routines, often crystallised within artifacts; 5) encoded knowledge, symbolic knowledge which can be codified and recorded in an explicit form as books, memos, letters, digital records, and so on (c.f. Collins, 1993).

There are also taxonomies of knowledge which attempt to combine its referential and situational dimensions. In an effort to theorise the tradeability of knowledge assets, Winter (1987) and Teece (1998) employ a continuum-based classification which distinguishes knowledge according to whether it is tacit or articulable, and if the latter, whether or not it is indeed articulated; whether or not it can be taught; whether or not it is observable in use; whether it is complex or simple in terms of the volume of information needed to characterise it; and whether it is systemic or independent (see also, Teece, 1981). Fleck (1996; 1997) explicitly attempts to relate the content of knowledge to the distinctive ways in which it is embodied. This results in a wide-ranging taxonomy which comprises the following components: 1) formal knowledge, that which is theoretical/conceptual and communicable in symbolic form; 2) instrumentalities, knowledge which is enacted through practice, drawing heavily on informal, tacit, and contingent dimensions of knowledge, and acquired through action and observation; 3) informal knowledge, 'rules of thumb' learned through interaction and communicable in verbal and sometimes written form; 4) contingent knowledge, that which is dependent for its meaning on a particular context; 5) tacit knowledge, embodied within individuals and grounded in action and experience; 6) meta-knowledge, acquired through socialisation processes and relating to values, norms, and assumptions constituted at a variety of scales (group-based, organisational, societal).

There seems to be an almost endless procession of alternative knowledge taxonomies (c.f. Blumentritt and Johnston, 1999). However, as Blackler (1995, 233) has usefully

observed, it is important to move beyond a preoccupation with defining different forms of knowledge and begin to analyse their interactions and relationships. By their nature, such taxonomies tend to rely upon decomposing and dissecting knowledge into discrete segments which, left as they are, do violence to the connectedness, involution, and sometimes sheer indivisibility of different modes of knowledge and knowing.[4] The difficulty of disassembling knowledge into disjunctive categories is often apparent in such taxonomies where one consistently finds an inability to speak of one manifestation of knowledge without making reference to the others. Fleck (1996; 1997), for example, reserves a separate category for tacit knowledge and yet this appears as an important component both of instrumentalities and informal knowledge. Having said that, attempts to provide taxonomies of knowledge do at least highlight its multifarious character. What is more serious is the tendency in some accounts of KM to ignore certain types of knowledge completely, whilst reifying others. This is significant because from such assumptions about the nature of knowledge flows a certain understanding of its manageability.

Thus, what one often finds in KM accounts is a preoccupation with the distinction between tacit and explicit knowledge, or more particularly, with the possibility of translating tacit into explicit knowledge. Clearly this is wholly consistent with the portrayal of organisations as rich repositories of untapped knowledge which could be more profitably exploited. The work of Nonaka (1991; 1994) and Nonaka and Takeuchi (1995) has been particularly influential in promoting this view. Although their arguments permit a more nuanced reading, this is frequently overlooked with the focus falling almost exclusively on their claims about the conversion of tacit to explicit knowledge. Making what has become an obligatory reference to Polanyi (1966, 4), tacit knowledge is defined through the phrase: "We can know more than we can tell". According to Nonaka (1994, 16):

> Tacit knowledge involves both cognitive and technical elements. The cognitive elements center on ... 'mental models' in which human beings form working models of the world by creating and manipulating analogies in their minds ... By contrast, the technical element of tacit knowledge covers concrete know-how, crafts, and skills that apply to specific contexts.

Explicit knowledge, by contrast, is that which can be articulated, codified, and formally expressed. For Nonaka and Takeuchi, knowledge is created through a series of conversions between tacit and explicit knowledge which may take four forms: 1) socialisation is the sharing of tacit knowledge between individuals, especially through observation and imitation in the context of shared experience; 2) combination involves the exchange and reordering of existing explicit knowledge to create new explicit knowledge; 3) internalisation involves the conversion of explicit to tacit knowledge and includes an important action dimension; and 4) externalisation refers to the conversion of tacit into explicit knowledge. It is this fourth mode of knowledge conversion which appears to have attracted most interest within certain areas of the KM literature.

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[4] "Rather than analyzing the world into discrete components, reducing their manyness to the One (= Two) of self-reflection, and ordering them by rank, it sums up a set of circumstances in a shattering blow. It synthesizes a multiplicity of elements without effacing their heterogeneity or hindering their potential for future rearranging" (Massumi, 1992, 6).

If, for the time being, we accept the proposition that tacit knowledge can be codified, this has significant implications for the creation and distribution of knowledge within organisations. Since tacit knowledge has a crucially personal and highly localised character, being gradually acquired through engagement in specific action contexts, there are important limitations to its transferability. However, according to Dutta, 1997, 81), "[a] company derives true benefits from its knowledge assets only when they are leveraged via a knowledge network, and diffused throughout the organization". Consequently, such localised knowledge represents a barrier to the organisation-wide exploitation of its full range of potential knowledge assets. The response has thus been to explore "strategies and processes of identifying, capturing, and leveraging –knowledge to help the firm compete" (O'Dell *et al.,* 1996, 7). Codification is seen as the first step to the wider dissemination and use of knowledge.

Indeed, this has become one of the central claims of numerous consultants and software suppliers offering KM services and technologies. One consultant, for example, advertises its products using the metaphor of the *Knowledge Line* which describes a stage-by-stage movement from the creation of knowledge, to its capture, codification, and classification, after which it can be communicated and re-used more widely within the organisation (Knowledge Ability, 1999).

ICTs are frequently accorded a significant supporting function in the process of capturing, codifying, and transferring knowledge (Croy *et al.,* 1997). As Davenport *et al.* (1997) have argued:

> Much of the energy in knowledge management has been spent on treating knowledge as an 'it', an entity separate from the people who create and use it. The typical goal is to take documents with knowledge embedded in them - memos, reports, presentations, articles, etc. - and store them in a repository where they can be easily retrieved.

Organisations are experimenting with a whole range of ICT-based tools (Intranets, groupware, databases, search engines, etc.) in an effort to facilitate the capture and sharing of knowledge (Ruggles, 1998). These tools often feature prominently in stories about 'exemplar' companies repeatedly incanted in reports and at conferences. For example, Price Waterhouse is reported to have introduced a Lotus-Notes-based system to good effect, a central feature of which was the creation of a centralised group to capture and document best practices (O'Dell *et al.,* 1996). Similarly, Buckman Laboratories, through the establishment of its *K'Netix* network, established the architecture through which it was possible to exchange, store, and retrieve knowledge electronically (Pan and Scarbrough, 1999). However, as we shall see in the next section, the majority of accounts of KM have quickly evolved from an earlier preoccupation with the role of ICTs to depict them more in terms of a necessary but not sufficient aspect of KM, particularly coming to focus on the cultural dimensions of knowledge sharing (Scarbrough *et al.,* 1999). Nevertheless, we will argue that, despite this shift in emphasis, the codification, depersonalisation, and disembodiment of knowledge still remains the ultimate goal of many KM approaches.

PUTTING KNOWLEDGE IN ITS PLACE: THE LIMITS OF CODIFICATION

ICT-led approaches to KM have by no means gone unchallenged. At its most extreme, the perception that KM is inseparably linked to an unsupportable over-emphasis on ICT tools has led to a rejection of KM in its entirety (e.g. Schrage, 1998). More typically, however, KM discourses have attempted to accommodate criticisms of an excessive ICT focus by incorporating a cultural dimension to their understanding of organisational knowledge practices. ICT tools are regarded as insufficient on their own because the mere fact they are available does not mean that individuals are willing to use them to share information (Nahapiet and Goshal, 1998). Consequently, considerable attention has been directed at the conditions that support or inhibit knowledge sharing. According to the Cambridge Information Network (1999, 17-20), "[c]reating a learning, knowledge-sharing organization often requires much more than just installing technology ... Instead, cultural issues are the number one challenge". Thus, returning to the earlier example of Buckman Laboratories, there was a clear recognition among senior management that the ICT architecture played a necessary but limited role in the development of its KM approach. Much more important was cultural change, which involved breaking down ingrained tendencies to hoard knowledge, encouraging an environment of continuity and trust, and providing incentives to share knowledge (Pan and Scarbrough, 1999). However, beyond the recognition that people are somehow central to the creation, sharing, and use of organisational knowledge, there is little agreement about how the requisite cultural conditions can be created.

Arguably, the cultural turn in KM approaches represents a simple extension of the codification strategy and epistemology of possession inherent in many ICT-led approaches rather than a departure from them. Knowledge is still regarded as something that individuals possess and the challenge is now not simply a technical one of providing the infrastructure to enable it to be captured and distributed, but also a socio-cultural one of motivating people to make them willing to yield up this knowledge for organisational use (c.f. Davenport *et al.,* 1997). However, this leaves unquestioned the extent to which codification, or the formal articulation of knowledge in an explicitly communicable and recordable form, is either possible, useful, or appropriate under all situations. There are a number of critiques of KM approaches focusing on the social construction and embeddedness of knowledge which cast doubt on this (e.g. Blackler, 1995; Boisot and Griffiths, 1999; Fleck, 1996; Gherardi, 1999).

In part, the persistent calls to make tacit knowledge explicit are based on a misunderstanding of the relationship between tacit and explicit knowledge, which the work of Nonaka and Takeuchi (1995) has done little to dispel. Despite defining tacit knowledge as that which is inarticulable, it is nevertheless claimed that tacit can be converted into explicit knowledge. The suggestion is that such a conversion occurs through the use of metaphor, which "depends on imagination and intuitive learning through symbols, rather than on the analysis or synthesis of common attributes shared by associated things" (Nonaka, 1994, 21). Through metaphor, contradicting concepts are brought within a single association, which may then be resolved into a more structured and logically formal relationship within an analogy. However, as Cook and Brown (1996, 14, emphasis original) have suggested:

> It is important ... not to confuse using one type of knowledge as an aid to acquiring the other with one being *converted* into the other. Tacit knowledge is not changed or 'surfaced' when used as a tool in learning something explicit, nor is explicit knowledge changed or 'submerged' when used as a tool for learning something tacit.

The fixation with converting tacit into explicit knowledge also tends to divert attention away from Polanyi's original concern with tacit knowing as an act of *indwelling*, where tacit knowledge is an ever-present dimension of any knowing act. The implication of this is that the focus within many accounts of KM on surfacing tacit knowledge, capturing, codifying, and transferring it, would at best be incomplete, and at worst totally miscast. Even if localised knowledge can be rendered into an explicit form, that is only half the story. If that knowledge communicated in explicit form is to be used by somebody else, then the tacit understanding of that individual will influence how it is interpreted. Even the most codified knowledge is meaningless when divorced from the process of knowing:

> Successful identification of actual locations with points on a map depends upon the good judgement of a skilled map-reader. No map can read itself. Neither can the most explicit possible treatise on map-reading read a map (Polanyi and Prosch,1975, 30).

At one level, this highlights the character of communicative practices as the negotiated construction of meaning which is strongly influenced by the existence of overlapping frames of reference or mental models, mutually comprehensible symbolic structures, and a shared appreciation of alternative genres of communication (e.g. Dixon, 1994; Hayes and Allison, 1998; Kim, 1993; Orlikowski and Yates, 1994). As Bannon and Kuutti (1996, 10) have argued, "while records can be stored, on each occasion of 're-use', actors must develop a common information space in which meanings are developed". Thus, the limits to codification are in one sense implied by the cognitive and normative bases of communicative interactions. There is considerable work in the area of organisational learning on the 'disorders', blockages, and misalignments that can make the shared negotiation of meaning anything but straightforward (e.g. Bain, 1998; Cohen and Levinthal, 1990; Levinthal and March, 1993; Snyder and Cummings, 1998). However, there is also another sense in which tacit knowledge can be understood which places it beyond the reach of explicitly constituted communicative practices. This emphasises the practical dimensions of knowing and the centrality of participating in action. Explicit or codified knowledge may provide a representation of how or why one does something, but it is inadequate without the practical knowledge developed through- participation in that practice. As Gherardi (1999, 115) has argued:

> The propositional knowledge of how to make a chair, and how to describe the process, is qualitatively different from knowing how to use a plane (practical knowledge) or from knowing when the blade needs changing. There is knowledge transmitted through the senses by virtue of familiarity with previous situations and of the refinement of the sensibility.

This further reinforces the importance of considering knowledge not simply as a stable and unproblematic object that can be effectively decontextualised and freely circulated, but as a complex, dynamic, and situated series of processes. At the same time, the over-emphasis on surfacing tacit knowledge tends to encourage an individualistic view of knowledge activities, primarily because tacit knowledge is

closely associated with personal knowledge (Polanyi, 1958). The spiral of knowledge creation proposed by Nonaka (1994) depicts a largely linear process of amplification which begins with the individual and spreads outwards to encompass groups and organisations. However, while one can hardly deny the centrality of individuals to the act of knowing, it is important to understand such acts as being embedded in specific material and social contexts. Fleck (1996) captures something of this through the concepts of domain, situation, and milieu. Domains refer to the particular areas on which knowledge is focused; situations comprise the assemblages of people and artifacts present at any one time; and milieux refer to the character of the immediate physical and social environment within which knowing activities take place. "It is through the generalized discourse with other actors and inanimate objects in given situations and milieux that the local rules of engagement are established and certain things become possible or not possible" (Fleck, 1996, 121). Gherardi *et al.* (1998, 274) similarly argue that "[k]nowledge is not what resides in a person's head or in books or data banks. To know is to be capable of participating with the requisite competence in the complex web of relationships among people and activities". Furthermore, they emphasise the importance of regarding the context of knowing activities as actively co-produced rather than a static container for action.

The contingent character of knowledge has crucial implications for the ability to disembed it from specific social and material contexts. This makes any depiction of knowledge-as-object, where it can be unproblematically captured, stored, transferred, and re-used, difficult to sustain. An understanding of knowledge as process rather than as a thing has made some inroads into the KM literature, particularly through the notion of 'communities of practice' (Brown and Duguid, 1991; Lave and Wenger, 1991). These emphasise networks of individuals bound together by participation in particular types of practice, forming the basis for some level of shared understanding and the co-production of knowledge through dense interaction. However, despite this growing appreciation of the social character of knowledge/knowing, it nevertheless appears that many organisations still focus their efforts on codification strategies. This is not to suggest that attempts at codifying or articulating knowledge are wholly irrelevant. As Winter (1987, -172) has suggested, "the failure to articulate what is articulable may be a more severe handicap for the transfer of knowledge than tacitness itself". While taking Winter's point, neglecting to recognise the limits of codification would be a serious omission.

PROJECT LEARNING IN COMPLEX PRODUCTS AND SYSTEMS

This section draws on initial findings emerging from research examining project learning in the production of complex products and systems, conducted by the CoPS Innovation Centre. It is based on a series of mini case studies, each involving in-depth semi-structured interviews with individuals at three different levels of the organisation: typically a senior manager, a project manager, and a practitioner working under the project manager. At present, case studies have been carried out with seventeen companies, although the ultimate intention is to expand this number to approximately fifty.

The character of complex products and systems production raises a number of

important challenges for the management of organisational knowledge. Its typically project-based nature introduces discontinuities which make it problematic to carry forward generalised lessons. This is exacerbated by the frequently customised or one-off nature of such products, which involve constantly changing client requirements and high levels of novel design input. The need to integrate diverse components and subsystems into a unified product architecture creates further challenges in terms of bringing together varied knowledge bases, which in turn often span across organisational boundaries.

In some instances, organisations which occupy the role of system integrator have taken on board activities outside of their traditional core competences (such as financing, planning, and turnkey project management) and have had to resolve issues of how to develop expertise in these areas. Simultaneously, many companies have undergone extensive personnel reductions and increased outsourcing which mean that they find it more difficult to retain knowledge and experience within the firm. However, while initial findings from the research indicate a variety of approaches to managing knowledge within and between such organisations, there nevertheless appears to be a dominant faith in the utility of codification strategies. While we have chosen only four company cases to illustrate this trend, they are by no means atypical of the overall picture emerging from the wider sample of organisations. For reasons of confidentiality, the names of the companies are not revealed.

Firm A: Consulting Engineers

Firm A is a consulting engineering firm that possesses knowledge and expertise across a broad range of civil engineering sectors, providing design and management services for projects as diverse as maritime structures, roads, railway stations, bridges, as well as mechanical and electrical engineering-intensive structures for commercial or industrial use. Managers at Firm A identified two problems with the company's knowledge management:

(1) Much of the important knowledge in the organisation is reported to reside in the heads of senior engineers. More junior engineers waste substantial amounts of time trying to locate and gain access to a senior engineer with the know-how to help solve a problem on a current project. The senior engineers' knowledge arises from experience of successive projects and its management is left very much to the individuals. Many keep indexed personal libraries of technical documentation, notes on lessons learned and drawings but these are not accessible beyond the individuals.

(2) A corollary of the first problem is that the senior engineers are increasingly reaching retirement age. There is little knowledge transfer from the retiring engineers to their successors and juniors. Consequently, the knowledge they have gained retires with them. There is a perception that this knowledge has been gained at the company's expense and it has some rights over it. As a Technical Director commented: "Most of the things I've learned I've learned because I've made mistakes...In fact, all of my experience has come out of this firm's turnover at some time or another".

Senior management is proposing to resolve these problems through the introduction

of: (1) a real-time project reporting system, where problem solving and lessons learned are captured and codified as they occur, this would be then be stored on an Intranet; and (2) brainstorming meetings with retiring directors.

There is a contradiction in the expectations for the Intranet and the beliefs of those implementing it. The senior manager interviewed expected that the Intranet would effectively replace the need for finding and consulting people in order to solve everyday problems. This was in spite of this manager's sophisticated understanding of knowledge transfer between people, which he maintains is primarily through storytelling. Despite the acknowledgement of the limitations of codification, KM strategies tend to revert to exercises in codification. The current reality in Firm A is that practitioners rarely use the Intranet, particularly as there are few points of access around the organisation.

The problem of retiring directors is being tackled through rather softer approaches. A particular director with extensive knowledge of a specific market in Africa is due to retire. Senior management plans to convene brainstorming sessions involving the retiring director, the succeeding director and others with experience of working in this market. The goal of the exercise is to capture information on all useful contacts, the nature of projects completed, problems and notable successes, and the location of documents. An opportunity for reflection is incorporated through actionable items following the meeting and a subsequent follow-up meeting two weeks later.

While a softer approach, this project is also aimed at the urgent codification of the tacit knowledge of the retiring director. It was felt that a gradual handing-over or mentoring period would not work, as the retiring director had no real incentive to share the knowledge or even the working of his filing system with his successor. "We've got to make a project out of it" commented the Technical Director. This reveals the truly ingrained culture of retaining knowledge in the company - senior engineers would sooner take their knowledge with them into retirement and beyond, than share it.

Firm B: Turnkey Rail Systems Manufacturer and Integrator

Firm B provides turnkey rail solutions, designing and building the rolling stock, developing control systems and bringing in necessary partners to provide track construction, operations and maintenance as well as legal and financial expertise. Knowledge management for this firm is driven by a perceived need for standardisation of products and procedures across its various international divisions. This is because local variation of products is seen as inefficient and frustrating to repeat customers. 'Centres of Competence' are being established in the key technologies which will act as repositories of knowledge and documentation. Experts in these areas of competence (signalling, bogies, carriages, etc.) will co-ordinate the formal codification of product design and project management procedures for the entire group. These will be disseminated and accessible through a global network linked to object-oriented databases.

The corporate goal is for engineers and managers to refer to and implement the prescribed designs and procedures such that no design change will occur during a

project. Similarly, projects should not be advanced to the next major stage without committee validation, which refers to checklists set by the Centres of Competence. The ICT infrastructure is to support this top-down initiative aimed at common products and best practices across the entire firm of 24,000 employees. Lessons learned are being collected from practitioners and codified to identify best practices. An Engineering Manager evangelising the initiative commented: "If you're a company you have to take the knowledge out of people. You have to, to go forward, otherwise you'll be constantly reinventing the wheel".

Interviews with project managers and practitioners revealed sparse awareness of the prescribed procedures and unfamiliarity with the systems and even the name of the initiative. While in most cases the project managers are reliant upon tacit knowledge gained through experience, they are sympathetic with the goals of the strategy. A structured and set product development process is a source of comfort to the project manager as it reduces risk and uncertainty. Engineers will be addressing risk before the project stage. "It allows the process to become scientific, optimisation not damage limitation. It means there are less surprises" (Firm B Project Manager, authors' interview).

This last comment is germane, as surprises often stimulate the inception of new knowledge. To remove the opportunity for surprises is to constrict the generation of new knowledge from everyday processes. Firm B's KM strategy is run the risk of eliminating innovation from projects through an over-dependence on codified procedures. Again, this KM strategy is attempting to solve a perceived problem of product and process inconsistency by establishing codified guidelines. However, it has thus far not permeated the organisation to a high degree.

Firm C: Research & Consulting Organisation to the Defence Industry

Firm C is a large research organisation providing services to governments and the private sector. These cover an array of disciplines such as weapons, chemical and biological defence, control systems and other electronics, and information management. The firm does develop some instrumentation, models and prototypes, but the vast majority of its product is intangible: design and technical specifications; test and evaluations, feasibility assessment reports; market surveys; and other advice. KM is therefore a critical strategic concern for this firm, as it reviews its position in the context of post-Cold War restructuring in the defence industry, as well as its own gradual privatisation.

A Chief Knowledge Officer (CKO) has been appointed with substantial resources available. The CKO's KM team is implementing a programme based largely around ICT infrastructure, involving an Intranet, upgrades to systems architecture and an ERP system. The model the firm is implementing involves a central repository called the 'Knowledge Store' where the organisation's employees are intended to deposit useful data. This data will need to go through a process of validation and approval before being accepted into the repository, similar to the academic publishing process. The incentives for submitting a publication to the Store are thought to be peer acclaim, and the satisfaction of being cited.

This strategy therefore assumes that practitioners are motivated to write and submit documentation. However, there is recognition in the KM team that practitioners rarely take time to write literature which is not directly contributing to a client study. A KM Programme Manager acknowledged the overt codification strategy remarking that "The explicit bit is the easier bit...". Moreover access to the Knowledge Store is configured towards individual users. Group learning and knowledge transfer is envisaged to occur through collaborative working environments such as groupware as well as more informal activities such as chat rooms and discussion groups. The KM team will set up the necessary tools and systems and will hope that these groups will emerge. They are encouraged by one particular discipline, the mathematicians, who have established an active online discussion group at their own initiative.

A perceived problem with Firm C is the persistence of working practices from a more comfortable era. Practitioners tend to work on a *process* basis, perhaps lacking the urgency and organisation that project-based workflows bring to bear. A project management consultancy division has been created to promote principles of working within constrained budgets, meeting deadlines, diligent planning and implementation. These principles are devised by experienced project managers who are recruited for the task. Again, these recommended procedures are encoded onto a `Knowledge Net' on the corporate Intranet. Thus far practitioners are working very much in traditional ways and have not taken on the project management practices.

Firm D: Architectural Design Consultants

Firm D has specialised experience in the design of buildings for aviation and has recently been subsumed into a larger group with an aggressive acquisitive strategy. This firm is trying to redirect corporate strategy towards a knowledge management approach that includes the network of external firms and contract workers who are associated with projects. This thinking is motivated by the temporary nature of project-based organisations, where flows of knowledge and information cross corporate boundaries. This necessary interaction is driven by the increasing complexity of the kind of airport terminal structures and systems that Firm D is engaged with.

The pressing problem is seen as the need to incorporate the knowledge of collaborators and engender their commitment to projects. At the same time an inclusive approach to contract workers - referred to by managers as "knowledge workers"- is intended to enlist their commitment to the project and the company, as typically these contract workers will be dedicated to Firm D's projects for several years. Alternatively, if they leave they take accumulated knowledge with them and the company loses access to it.

However, in terms of tangible measures to achieve the desired type of "virtual" organisation, the emphasis is on technical systems: "...tools flexible enough to allow us to sort of mesh and come apart again whenever we need...trying to come up with a truly collaborative cross-functional team so you can't tell who works for who and who does what...So if you can get that culture to work, and that organisation, then everything starts to click. And what we're trying to do is find the tools to help us to do that" (Senior Manager).

In practice this means systems that allow the transmission and sharing of large files, so that Firm D and its collaborating designers will have shared access to the models they work with. This is intended to cut down on rework as pieces of drawings from prior projects may be cut and integrated into new contexts. Lessons learned from different projects are communicated through contact between engineers, but this is not seen as intrinsic to knowledge transfer, but rather a suboptimal temporary arrangement that will continue until IT tools are advanced enough to handle the process: "Now until we get the right tools, whether it's the Internet or relational or relationship type databases, we will continue to use people to do that" (Senior Manager).

However, operational problems associated with this approach were expressed by a Project Engineer who warned of the dangers of Intranets, emails and electronic repositories, from a project management viewpoint. The danger is that drawings posted on a website or sent through email tend not to get checked as diligently as paper copy, as a consequence of information overload. The danger of this neglect is that structures are incorrectly built on site. These operational issues suggest limitations to the codification strategy being pursued by Firm D. This Project Engineer insisted on personal contact as the most effective means of communication.

DISCUSSION AND CONCLUSIONS: CoPS PROJECTS AND EMBODIED KNOWLEDGE

These four cases reveal two opposing tendencies. On the one hand, there is a dominant emphasis on capturing localised knowledge and making it explicit through codification so that it is amenable to wider distribution and re-use, typically involving some sort of ICT infrastructure. On the other hand, there are indications that managers and employees are implicitly aware of the social and contingent nature of knowledge/knowing and thus of the limitations of codification. For example, the sharing of expertise through face-to-face contact within and between project teams was regularly identified as a central feature of resolving issues and problems and generating new ideas. Yet, as was seen in the cases of Firms A and D, there was an anticipation that personal contact could be somehow supplanted through the increasing sophistication of mechanisms for capturing, storing, and transferring knowledge. To conclude, we suggest some possible interpretations of these apparently inconsistent tendencies, more with the intention of identifying avenues for further investigation than to provide definitive answers.

Much of the knowledge management literature has been concerned with mass production industries. The emphasis on transforming tacit into explicit knowledge has been a strategic priority in these industries since Smith's articulation of the division of labour in pin-making. In the last century Frederick Taylor's `scientific management' was a powerful codification of productive knowledge which reduced the reliance on tacit, accumulated craft-based skills. More recently the routines of lean manufacturing have been codified in texts and workbooks by consultancies, academics and management gurus. These have all been extremely powerful and successful codifications of process-based productive knowledge.

The four cases of this study show top managers attempting to cope with the problems of project-based organisation and the development of complex products and systems. The root problem is the co-ordination and integration of multifarious knowledge bases that reside in different individuals, teams, divisions and partner firms. By comparison to mass production industries, where routines are repetitious and tasks are easily codified, the development of CoPS is dependent upon tacit knowledge. The perceived imperatives of management are to reduce dependence of this tacit knowledge, which appears inappropriable to the firm.

The pressures created by the project-based character of CoPS production provide one possible insight into why codification strategies are regarded as attractive. Managers are keenly aware of the potential dangers of over-reliance on key individuals or groups for their knowledge and experience, which may become unavailable if they exit the organisation. However, even if individual project members are retained within the organisation, there is still the issue of their availability for particular projects. Consequently, if this knowledge could be effectively depersonalised or disembodied, appropriated from individuals, then the impact of exit or unavailability could be lessened (c.f. Mueller and Dyerson, 1999). Under conditions of intense competition and stringent time pressures which militate against employment continuity and tend to fragment social networks, a reliance has been placed on codifying and disembodying knowledge in the hope of filling the vacuum left behind.

As a response to these problems, these four knowledge management strategies are all attempts to capture knowledge through codifying it, and disseminating it through technical systems. While these initiatives are at an early stage there is little evidence or basis to believe that IT-based KM systems will be widely used by practitioners. In most cases their success will require substantial effort and interest from practitioners beyond their everyday duties. Given the pressures of project-based business, it will be remarkable if these initiatives make a major difference to the knowledge management of these firms. Nevertheless KM strategy reverts to codification, probably because of the experience of mass production industries; it is perceived to be easier than the transfer of tacit knowledge.

Although based on a misapprehension about the nature of knowledge/knowing, this nevertheless provides a plausible explanation for why managers are keen to explore the potential for codification. What it does not explain is the discrepancy between the pursuit of codification strategies and the recognition of their limitations. Appropriate here may be the notion that competing rationalities can coexist without any necessary resolution. Just because the insufficiencies of a particular conception are recognised does not mean that its implications are actually followed through. Interestingly enough, these questions move the debate further away from the concerns of KM and closer to those which have occupied the literature on organisational learning, focusing on the different ways that knowledge and knowing are embodied.

REFERENCES

Amidon, D.M. (1995) 'The momentum of knowledge management'. Wilmington, MA: Entovation International.

Amit, R. and Shoemaker, P.J.H. (1993) 'Strategic assets and organizational rent'. *Strategic Management Journal* 14: 33-46.

Argyris, C. and Schön, D.A. (1978) *Organizational Learning: A Theory of Action Perspective.* Reading, MA: Addison-Wesley.

Ashmore, M. (1989) *The Reflexive Thesis: Writing Sociology of Scientific Knowledge.* Chicago, IL: University of Chicago Press.

Bailey, J. (1997) *After Thought: The Computer Challenge to Human Intelligence.* New York: Basic Books.

Bain, A. (1998) 'Social defenses against organizational learning'. *Human Relations* 51(3): 413-429.

Bannon, L.J. and Kuutti, K. (1996) 'Shifting perspectives on organizational memory: from storage to active remembering'. *Proceedings IEEE HICSS 96, Hawaii, January.*

Barney, J.B. (1991) 'Firm resources and sustained competitive advantage'. *Journal of Management* 17: 99-120.

Bartlett, C.A. and Ghoshal, S. (1993) 'Beyond the M-form: toward a managerial theory of the firm'. *Strategic Management Journal* 14: 23-46.

Bauman, Z. (1989) *Legislators and Interpreters.* Cambridge: Polity.

Bell, D. (1973) *The Coming of Post-Industrial society.* New York: Basic Books.

Bhaskar, R. (1979) *The Possibility of Naturalism: A Philosophical Critique of the Contemporary Human Sciences.* London: Routledge.

Blackler, F. (1995) 'Knowledge, knowledge work and organizations: an overview and interpretation'. *Organization Studies* 16(6): 16-36.

Blumentritt, R. and Johnston, R. (1999) 'Towards a strategy for knowledge management'. *Technology Analysis and Strategic Management* 11(3): 287-300.

Boisot, M. (1998) *Knowledge Assets: Securing Competitive Advantage in the Information Economy.* Oxford: Oxford University Press.

Boisot, M. and Griffiths, D. (1999) 'Possession is nine-tenths of the law: managing a firm's knowledge base in a regime of weak appropriability'. *Journal of Technology Management* 17(6): 662-676.

Bonaccorsi, A., Pammolli, F., Paoli, M. and Tani, S. (1996) 'Discontinuity and learning in system companies'. In: Butler, J. and Piccaluga, A. (eds.) *Knowledge, technology and innovative organizations.* Milan: Guerini, pp.147-174.

Bontis, N. (1996) 'There's a price on your head: managing intellectual capital strategically'. *Business Quarterly,* Summer, pp.41-47.

Bourdieu, P. (1988) *Homo Academicus.* Cambridge: Polity.

Brown, J.S. and Duguid, P. (1991) 'Organizational learning and communities of practice: toward a unified view of working, learning, and innovation'. *Organization Science* 2(1): 40-57.

Cambridge Information Network (1999) 'The knowledge paradox: how to manage your most strategic asset'. San Francisco, CA: Cambridge Information Network.

Clark, R.C. (1998) 'Recycling knowledge with learning objects'. *Training and Development* 52(10): 60-61.

Coff, R.W. (1997) 'Human assets and management dilemmas: coping with hazards on the road to resource-based theory'. *Academy of Management Review* 22(2): 374-402.

Cohen, W.M. and Levinthal, D.A. (1990) 'Absorptive capacity: a new perspective on learning and innovation'. *Administrative Science Quarterly* 35: 128-152.

Collins, H. (1993) 'The structure of knowledge'. *Social Research* 60: 95-116.

Connor, K.R. and Prahalad, C.K. (1996) 'A resource-based theory of the firm: knowledge versus opportunism'. *Organization Science* 7(5): 477-501.

Cook, S.D.N. and Brown, J.S. (1996) 'Bridging epistemologies: the generative dance between organizational knowledge and organizational knowing'. Mimeo, Palo Alto, CA: Xerox PARC.

Croy, N., Davenport, T., O'Dell, C. and Odem, P. (1997) *Using Information Technology to Support Knowledge Management: Consortium Benchmarking Study Final Report.* Houston, TX: American Productivity and Quality Center.

Davenport, T.H., De Long, D.W. and Beers, M.C. (1997) 'Building successful knowledge management projects'. Center for Business Innovation Working Paper, Ernst & Young LLP, January.

DiMaggio, P.J. and Powell, W.W. (1983) 'The iron cage revisited: institutional isomorphism and collective rationality in organizational fields'. *American Sociological Review* 48: 147-160.

Dixon, N. (1994) *The Organizational Learning Cycle: How We Can Learn Collectively.* Maidenhead: McGraw-Hill.

Drucker, P.F. (1993a) 'The rise of the knowledge society'. *The Wilson Quarterly* 17(2): 52-71.

Drucker, P.F. (1993b) *Post-Capitalist Society.* Oxford: Butterworth-Heinemann.

Dutta, S. (1997) 'Strategies for implementing knowledge-based systems'. *IEEE Transactions on Engineering Management* 44(1): 79-90.

Dutta, S. (1993) *Knowledge Processing and Applied Artificial Intelligence.* London: Heinemann.

Easterby-Smith, M. (1997) 'Disciplines of organizational learning: contributions and critiques'. *Human Relations* 50(9): 1085-1113.

Edvinsson, L. and Malone, M. (1997) *Intellectual Capital.* London: Piatkus.

Fayyard, U.M., Piatetsky-Shapiro, G. and Smyth, P. (eds.) (1996) *Advances in Knowledge Discovery and Data Mining.* Cambridge, MA: MIT Press.

Fleck, J. (1997) 'Contingent knowledge and technology development'. *Technology Analysis and Strategic Management* 9(4): 383-397.

Fleck, J. (1996) 'Informal information flow and the nature of expertise in financial services'. *International Journal of Technology Management* 11(1/2): 104-128.

Foucault, M. (1970) *The Order of Things: An Archaeology of the Human Sciences.* London: Routledge.
Gardner, H. (1985) *The Mind's New Science.* New York: Basic Books.

Gates, B.L. (1975) 'Knowledge management in the technological society: government by indicator'. *Public Administration Review* 35(6): 589-592.

Gherardi, S. (1999) 'Learning as problem-driven or learning in the face of mystery?'. *Organization Studies* 20(1): 101-124.

Gherardi, S., Nicolini, D. and Odella, F. (1998) 'Toward a social understanding of how people learn in organizations'. *Management Learning* 29(3): 273-297.

Goerl, G.F. (1975) 'Cybernetics, professionalization and knowledge management: an exercise in assumptive theory'. *Public Administration Review* 35(6): 581-588.

Gore, C. and Gore, E. (1999) 'Knowledge management: the way forward". *Total Quality Management* 10(4/5): 554-560.

Habermas, J. (1989) *The Theory of Communicative Action, Volume Two: System and Lifeworld - A Critique of Functionalist Reason.* Cambridge: Polity.

Habermas, J. (1984) *The Theory of Communicative Action, Volume One: Reason and the Rationalization of Society.* Cambridge: Polity.

Hansen, M.T., Nohria, N. and Tierney, T. (1999) 'What's your strategy for managing knowledge?'. *Harvard Business Review,* March-April, pp.106-116.

Hayes, J. and Allison, C.W. (1998) 'Cognitive style and the theory and practice of individual and collective learning in organizations'. *Human Relations* 51(7): 847-871.

Hedlund, G. (1994) 'A model of knowledge management and the N-form corporation'. *Strategic Management Journal* 15: 73-90.

Henry, N.L. (1975) 'Bureaucracy, technology and knowledge management'. *Public Administration Review* 35(6): 572-577.

Henry, N.L. (1974) 'Knowledge management: a new concern for public administration'. *Public Administration Review* 34(3): 189-198.

Hobday, M. (1998) 'Product complexity, innovation and industrial organisation'. *Research Policy* 26: 689-710.

Johnson, R.C. (1988) *Cognizers: Neural Networks and Machines that Think.* Chichester: John Wiley.

Katz, C. (1992) 'All the world is staged: intellectuals and the projects of ethnography'. *Environment and Planning D: Society and Space* 10: 495-510.

Kim, D.H. (1993) 'The link between individual and organizational learning'. *Sloan Management Review,* Fall, pp.37-50.

Knowledge Ability (1999) 'Knowledge management'. http://www.knowab.co.uk/km, 21 September 1999.

Latour, B. (1999) *Pandora's Hope: Essays on the Reality of Science.* Cambridge, MA: Harvard University Press.

Latour, B. and Woolgar, S. (1979) *Laboratory Life: The Social Construction of Scientific Facts.* Beverley Hills, CA: Sage.

Lave, J. and Wenger, E. (1991) *Situated Learning: Legitimate Peripheral Participation.* Cambridge: Cambridge University Press.

Levinthal, D.A. and March, J.G. (1993) 'The myopia of learning'. *Strategic Management Journal* 14: 95-112.

Lippman, S.A. and Rumelt, R.P. (1992) 'Demand uncertainty and investment in industry-specific capital'. *Industrial and Corporate Change* 1(1): 235-262.

Lotus Development Corporation (1998) 'Lotus, IBM and knowledge management'. Lotus White Paper, Lotus Development Corporation.

Marengo, L. (1992) 'Coordination and organizational learning in the firm'. *Journal of Evolutionary Economics* 2: 313-326.

Marshall, N. and Bresnen, M. (1999) 'The evolution of a fad: "partnering" in the UK construction industry'. Paper presented to Sub-theme 5 "Management Fashions and Fads" of the 15th EGOS Colloquium "Organizations in a Challenging World: Theories, Practices, and Societies", University of Warwick, Coventry, 4-6 July.

Massumi, B. (1992) *A User's Guide to Capitalism and Schizophrenia: Deviations from Deleuze and Guattari.* Cambridge, MA: MIT Press.

Millar, J., Demaid, A. and Quintas, P. (1997) 'Trans-organisational innovation: a framework for research'. *Technology Analysis and Strategic Management* 9(4): 399-418.

Moad, J. (1998) 'In search of knowledge'. *PC Week,* 7 December, pp.111-113.

Mueller, F. and Dyerson, R. (1999) 'Expert humans or expert organizations?'. *Organization Studies* 20(2): 225-256.

Nahapiet, J. and Goshal, S. (1998) 'Social capital, intellectual capital, and the organizational advantage'. *Academy of Management Review* 23(2): 242-266.

Nelson, R.R. and Winter, S.G. (1982) *An Evolutionary Theory of Economic Change.* Cambridge, MA: Harvard University Press.

Nonaka, I. (1994) 'A dynamic theory of organizational knowledge creation'. *Organization Science* 5(1): 14-37.

Nonaka, I. (1991) 'The knowledge-creating company'. *Harvard Business Review,* November-December, pp.96-104.

Nonaka, I. and Takeuchi, H. (1995) *The Knowledge-Creating Company.* Oxford: Oxford University Press.

O'Dell, C. and Grayson, C.J. (1998) 'If only we knew what we know: identification and transfer of internal best practices'. *California Management Review* 40(3): 154-174.

O'Dell, C., Wiig, K., Odem, P., Bodmer, C. and Mullinix, L. (1996) *Knowledge Management: Consortium Benchmarking Study Final Report.* Houston, TX: American Productivity and Quality Center.

Orlikowski, W.J. and Yates, J. (1994) 'Genre repertoire: the structuring of communicative practices in organizations'. *Administrative Science Quarterly* 39: 541-574.

Pan, S.L. and Scarbrough, H. (1999) 'Knowledge management in practice: an exploratory case study'. *Technology Analysis and Strategic Management* 11(3): 359-

374.

Pemberton, M.J. (1998) 'Knowledge management and the epistemic tradition'. *Records Management Quarterly* 32(3): 58-62.
Pickering, A. (1996) *The Mangle of Practice.* Chicago: University of Chicago Press.

Polanyi, M. (1966) *The Tacit Dimension.* London: Routledge and Kegan Paul.

Polanyi, M. (1958) *Personal Knowledge.* Chicago, IL: University of Chicago Press.

Polanyi, M. and Prosch, H. (1975) *Meaning.* Chicago, IL: University of Chicago Press.

Powell, W.W. and DiMaggio, P.J. (eds.) (1991) *The New Institutionalism in Organizational Analysis.* Chicago, IL: University of Chicago Press.

Prahalad, C.K. and Hamel, G. (1990) 'The core competence of the corporation'. *Harvard Business Review,* May-June, pp.79-91.

Ruggles, R. (1998) 'The state of the notion: knowledge management in practice'. *California Management Review* 40(3): 80-89.

Sayer, A. (1992) *Method in Social Science: A Realist Approach.* 2nd Edition. London: Routledge.

Scarbrough, H., Swan, J. and Preston, J. (1999) *Knowledge Management and the Learning Organization: A Review of the Literature.* London: Institute of Personnel and Development.

Scheraga, D. (1998) 'Knowledge management competitive advantage becomes a key issue'. *Chemical Market Reporter,* 26 October, p.3.

Schrage, M. (1998) 'Why no one wants knowledge management'. *ComputerWorld,* 7 December, p.N/A.

Senge, P.M. (1992) *The Fifth Discipline: The Art and Practice of the Learning Organization.* London: Century Business.

Snyder, W.M. and Cummings, T.G. (1998) 'Organization learning disorders: conceptual model and intervention hypotheses'. *Human Relations* 51(7): 873-895.

Speel, P-H. and Aben, M. (1998) 'Preserving conceptual structures in design and implementation of industrial KBSs [knowledge-based systems]'. *International Journal of Human-Computer Studies* 49: 547-575.

Stewart, T.A. (1998) 'Packaging what you know'. *Fortune,* 9 November, pp.253ff.

Stewart, T.A. (1995) 'Mapping corporate brainpower'. *Fortune,* 30 October, pp.209-212.

Sveiby, K.E. (1997) *The New Organizational Wealth.* San Francisco, CA: Berrett-Koehler.
Teece, D.J. (1998) 'Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets'. *California Management Review* 40(3): 55-79.

Teece, D.J. (1981) 'The market for know-how and the efficient international transfer of technology'. *Annals of the American Association of Political and Social Sciences,* November, pp.81-86.

Thurow, L.C. (1999) 'Building wealth'. *The Atlantic Monthly,* June, pp.57-69.

Winter, S.G. (1987) 'Knowledge and competence as strategic assets'. In D.J. Teece (ed.) *The Competitive Challenge: Strategies for Industrial Innovation and Renewal.* Cambridge, MA: Ballinger, pp.159-184.